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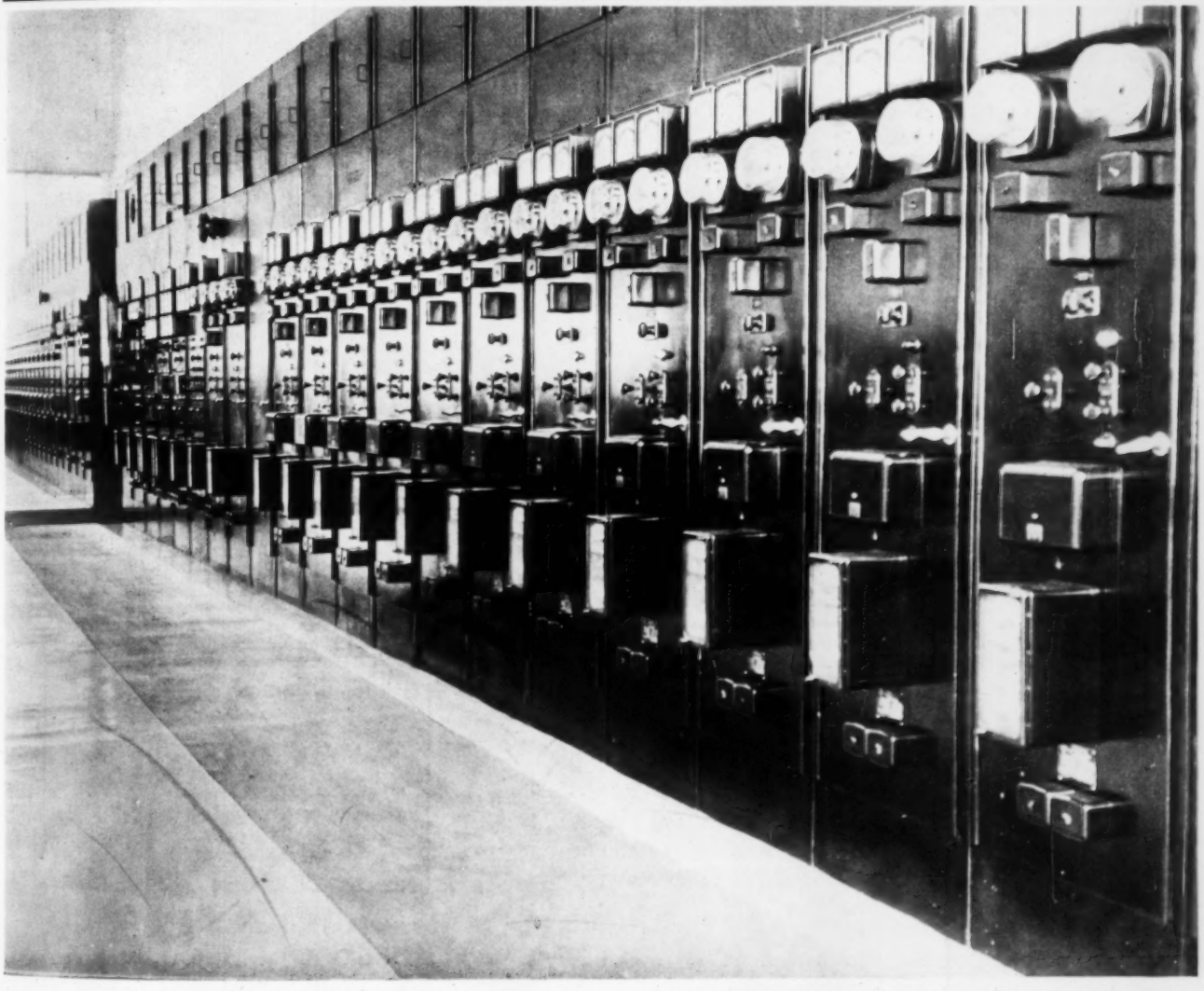
INSTRUMENTS

THE MAGAZINE OF

MEASUREMENT AND CONTROL

Volume 8 APRIL 1935 Number 4



SWITCHBOARD AT PANAMA CITY (FLORIDA) PLANT OF SOUTHERN KRAFT CORP.

(Courtesy General Electric Co.)

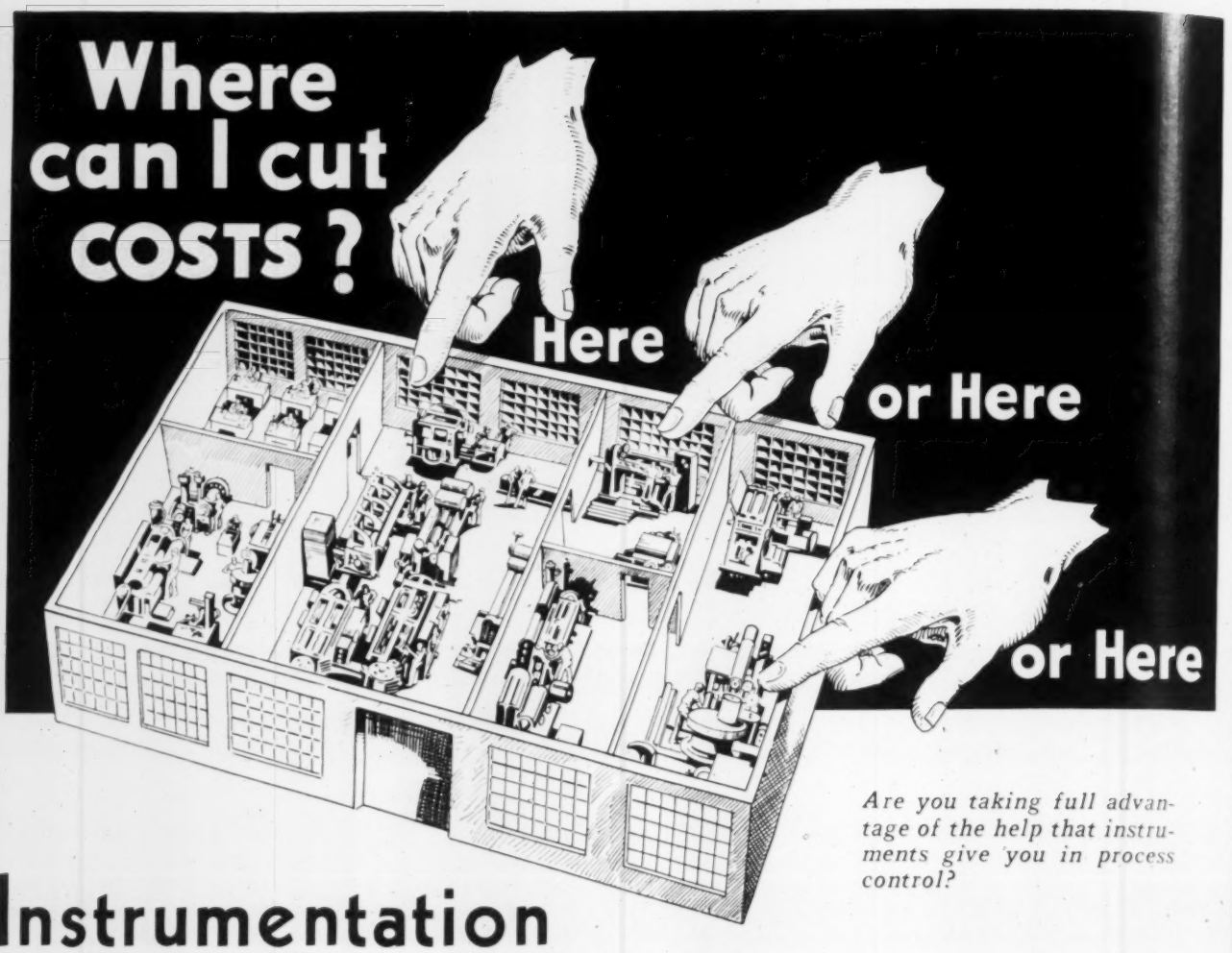


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Photo shows Colorimeters with Bakelite Molded cases. Invented by W. E. Reynolds and a product of M.R.H. Laboratories, Dowagiac, Mich.

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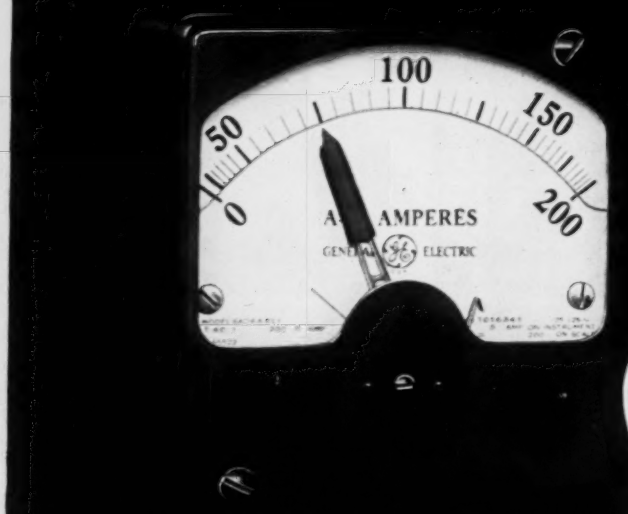

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430-48

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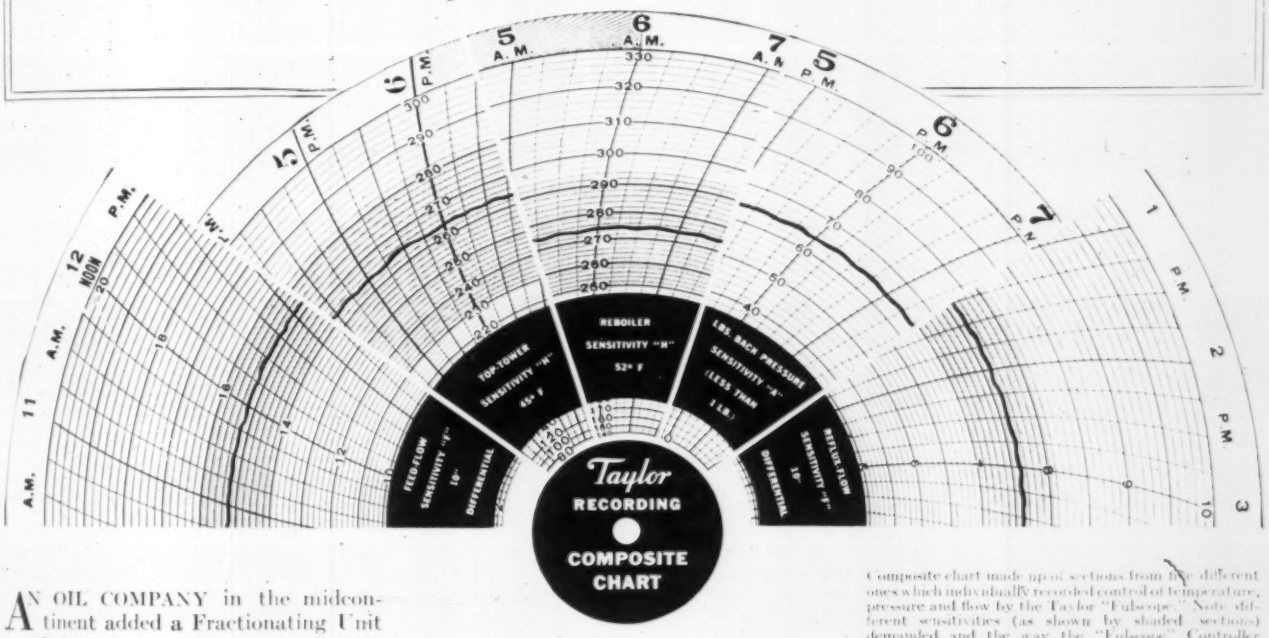

FEED-FLOW SENSITIVITY "F" 10" DIFFERENTIAL
TOP-TOWER SENSITIVITY "H" 45° F
REBOILER SENSITIVITY "H" 52° F
LBS. BACK PRESSURE SENSITIVITY "A" (LESS THAN 1 LB.)
REFLUX-FLOW SENSITIVITY "F" 10" DIFFERENTIAL
Taylor RECORDING COMPOSITE CHART

Composite chart made up of sections from five different ones which individually recorded control of temperature, pressure and flow by the Taylor "Fulscope." Note different sensitivities (as shown by shaded sections) demanded and the way the "Fulscope" Controller maintained straight-line control in each situation.

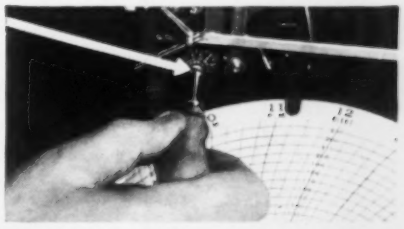
AN OIL COMPANY in the midcontinent added a Fractionating Unit to their refinery. Good control with steady throttling valve action was essential for flows, temperatures, and pressures . . . and there is *one best sensitivity* (or throttling range) for each application. The composite chart above shows what was required.

Flow control on the feed demanded Sensitivity F (10" water differential). Reflux Flow needed Sensitivity F (10" water differential). Reboiler Temperature control called for Sensitivity H (or 52° F.). Top Tower Temperature control demanded Sensitivity H (or 45° F.). Back pressure controls needed Sensitivity A (or less than one pound).

The different sensitivity (or throttling range) necessary for each operation was obtained by turning the "Universal Sensitivity Adjuster" of the Taylor "Fulscope" Controller to the proper point indicated on the dial by the letters. The operator used a screw-driver while the instrument was in action. No delays. No uncertainty. Instant adjustment. And straight line control that amazed the company's engineers.

Here is just one example of the way the new Taylor "Fulscope" meets your needs. Previously, controllers did not have a low enough or high enough sensitivity. "Fulscope" has the wide range from high to low that you need for temperature, pressure or rate of flow control.

Let us show you how the Taylor "Fulscope" can be used to simplify and answer your control problems. For this help, address Taylor Instrument Companies, Rochester, N. Y.; Tulsa, Oklahoma; Los Angeles, California; San Francisco, California; or Toronto, Canada. Manufacturers in England—Short & Mason, Ltd., London.



Taylor Fulscope Controller, with a close-up of the heart of the instrument, which is called the "Universal Sensitivity Adjuster." A screw-driver easily turns the adjuster to the correct sensitivity (lettered on the dial) for any control operation.

Taylor

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TEMPERATURE, PRESSURE *and* **FLOW INSTRUMENTS**

INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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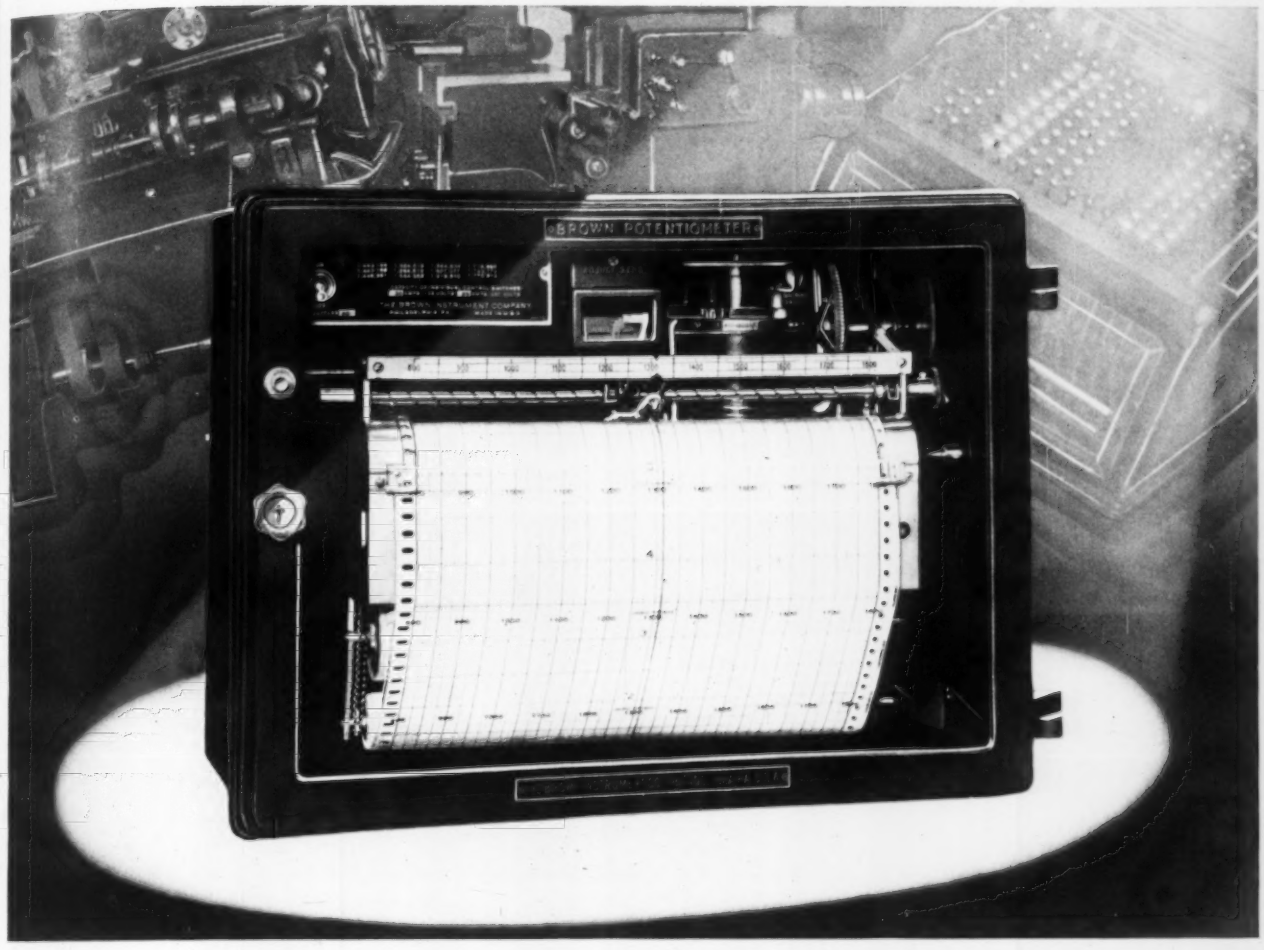
Published Monthly on the 15th by
The Instruments Publishing Company
1117 Wolfendale Street
Pittsburgh, Pa.
JOSEPH J. VIGNEAU, President
RICHARD RIMBACH, Vice-Pres.-Treas.

Branch Offices
Boston: James Condon, 6 Marlboro St.
New York: Edwin F. Ripley, 118 E. 28th St.
Glendale, Calif.: W. R. McIntyre, 1115 Tyler St.

Annual Subscription: U. S. $2.00. All other countries $3.00 (Remit by New York Draft).
Copyright 1935 by The Instruments Publishing Company.
Entered as second-class matter January 26, 1932, at the post office at Pittsburgh, Pa., under the Act of March 3, 1879.



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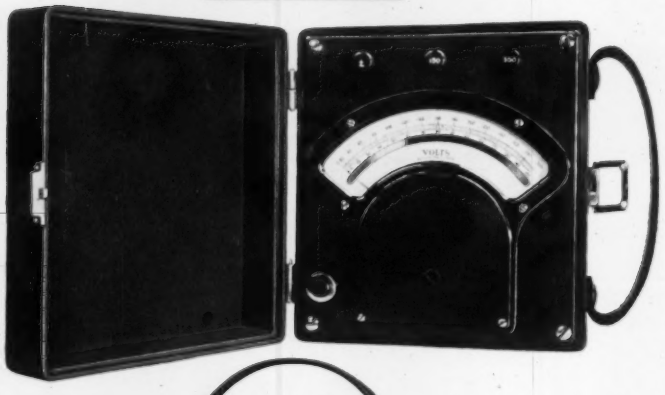
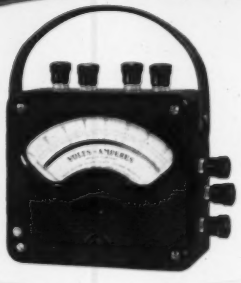


Type PY-5 Double-Range Voltmeter for A-C. Service. Case Size: 7¼" x 8⅛" x 4". This instrument typifies the Types PY-5 and PX-5 lines.



Type PX-4 Six-Range Volt-Ammeter for D-C. Service. Case Size: 4½" x 4½" x 2". All PX-4, PY-4 Instruments are similar.

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EDITORIAL COMMENT

In This Issue

A by-line appears *under* the title of this month's leading article. It really should be *part* of the title, thus: "How Altitude Records are Certified by W. G. Brombacher." Such indeed is the case—at least for record flights made in the United States. But Dr. Brombacher tells much more: even the footnotes under some of his tables summarize epics of aerial glory, frustration and stark tragedy. (Pages 86-87 *and 103.*)

Synchronizing involves some of the most baffling problems in electrical and mechanical engineering and in metallurgy. W. A. Holland tells how Instrumentation solved some of these problems. (Page 88.)

Thanks to Perry Borden's years of experience with the Ontario Hydroelectric Power Commission, this month's instalment on electricity meters contains data of interest to industrial users of electric power, including 17 connection diagrams made up especially for them. (The last illustration on page 96, by the way, shows a meter which has just been placed on the American market.)

And a quarter-century of electric metering experience underlies C. H. Thayer's article on testing for phase rotation. Page 98.

In his masterly history of testing machines, pages 99-102, C. H. Gibbons brings us this month to the modern types with their indicating gages.

Don't fail to read the discussions of recent articles ("True Direction" and "Scale Distribution") on page 102.

In the New Instruments Department there are reported two new *types* of devices. See if you can spot both!

The Front Covers

In connection with this month's chapter of our electrical measurements handbook, the front cover photograph is appropriate, for there are 88 single-phase and 44 polyphase meters on this GE switchboard, whence 16,000 h.p. are distributed by the Southern Kraft Corp. for running a 400-ton pulp mill as well as supplying light and power to the city of Panama City, Florida.

The Inspection and Testing title page shows an inspector at Taylor Instrument Companies calling out the corrections to another operator who fills out the certificates accompanying high-grade fever thermometers. Each tube is read six times in this manner, though in many cases, we are informed, the correction is found to be zero.

"In Time of Peace . . ."

SINCE Hitler upset the European apple-cart a few weeks ago by tearing up another "scrap of paper" which Germany had signed, the world is sitting on an H-E shell—a TNT shell with its percussion fuse armed.

We grant that Divine providence has given us the Atlantic and Pacific. We grant that Canadians are our blood brothers and that our southern frontier has been made safe since 1916. We grant that the danger of our being suddenly invaded need rob of sleep only those weaklings whom the Hearst and MacFadden tablopiates have robbed of thought. We go even further and divulge a fact unreported in the papers up to the time of writing (Army Day—April 6); that Hitler's "conscript army"—the large one forbidden by the Versailles Treaty—if mobilized before 1936 would be more of a mob than an army.

[Let it be made plain, moreover, that your editor hates war. He hates war not with the stomach-turning horror of a squeamish "intellectual" who faints at the thought of blood, but with the calm determination he shares with all other thoughtful veterans of the AEF. Because of his implacable hatred of war he devotes much of his time to preparing against it, and to preaching Industrial Preparedness.]

Convinced that *Instruments* readers love the United States, we think it timely, in view of war threats in Europe and in view of pending legislation in Washington, to devote this column to solemn reminders:

1. When war breaks out among Great Powers we shall be drawn in.

2. War is likely to break out soon in Europe, Africa and the Far East.

3. Modern warfare is mechanistic. It no longer is a battle between armies and fleets but it is a struggle in which each side strives to utilize the coördinated power of every individual and every material resource.

4. It requires a minimum of eighteen months for a nation whose engineers, industrial executives, scientists and research workers are untrained for their parts in an emergency, to mobilize its resources against aggression.

5. In less than eighteen months such a nation can be invaded, decisively conquered and brought to a shameful end.

6. In the First World War, America was forced to *extemporize* methods of directing the industrial effort. Section 5a of the National Defense Act of 1920 now charges The Assistant Secretary of War with supervising the procurement of all military supplies and with providing for the mobilization of matériel and of industrial organizations essential to war-time needs.

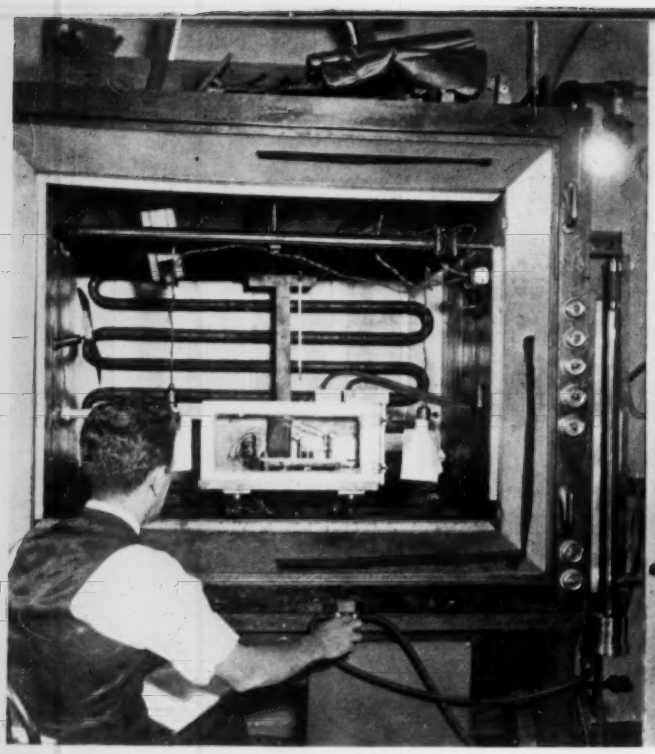
7. This huge task cannot be accomplished by the office of The Assistant Secretary without greater support from all industries. Up to now, relatively few manufacturers have assembled the fixtures, gages and other facilities required for changeover; few have devoted sufficient time or encouraged their engineers to devote sufficient time to industrial preparedness.

8. By the time this is printed, a "war-profit" law will probably have been enacted. From now on, therefore, it will require the purest and most self-sacrificing patriotism for industrial technicians and executives to prepare to serve America—at their own expense! This is precisely what we earnestly urge you to do! Get in touch with the nearest Army or Navy technical district office; fill out a list of your qualifications; enroll; and start training!

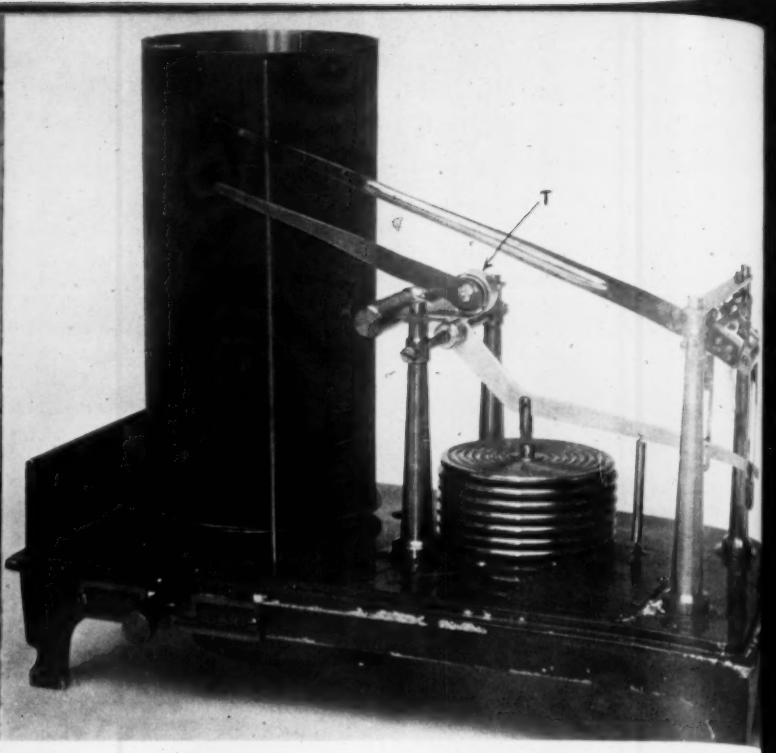
9. If you prefer joining a munitions preparedness movement without having to enroll in the Army or Navy Reserves, join the Army Ordnance Association (Mills Bldg., Washington, D. C.).

M. F. Behar

P. S. We practice what we preach. When this is printed we shall be on a two-week tour of active service (our ninth since the *First* World War).



Apparatus for testing barographs at the National Bureau of Standards. The pressure chamber in which the barograph is installed is shown inside of the temperature chamber. The standard altitude barometer is at the extreme right. E. L. Borlik is shown operating the vacuum control.



"Official" barograph installed on the stratosphere balloon which recorded the air pressure during the world's record stratosphere flight made by Lt. Com. Settle, U.S.N., and Major Fordney, U.S.A., on November 20, 1933. The instrument, made by J. P. Friez and Sons, Inc., is of the double-traverse type. Note the bimetal type instrument temperature recording element, T, added by the National Bureau of Standards.

How Altitude Records are Certified

By W. G. BROMBACHER*

IN making an international record for altitude in airplane and balloon flights it is now necessary to secure in flight only a record of the air pressure against time. The lowest pressure attained is converted to altitude by means of the altitude-pressure relation of the Fédération Aéronautique Internationale (FAI) standard atmosphere, which has been adopted internationally for such use. This relation is as follows:

$$Z = (K_1 + K_2 P + K_3 P^2) \log \frac{760}{P},$$

where Z is the altitude in meters; P is the air pressure in millimeters of mercury at the highest altitude; $K_1 = 15320$; $K_2 = 8.65$; and $K_3 = 0.0055$. Altitudes in this atmosphere for various pressures are given in Table I, together with corresponding altitudes in the United States Standard Atmosphere.

For high altitude flights a double-traverse barograph is generally used in this country to secure a record of air pressure against time. The trace is made by a stylus operating on a smoked chart of paper or aluminum sheet. Many of the barographs used contain a bimetallic element for recording the instrument temperature in order to afford data for eliminating the effect of temperature upon the readings of the instrument.

In this country the barograph is tested at the National Bureau of Standards at the request of the governing body, the National Aeronautic Association. The procedure consists essentially in subjecting the barograph to a flight history test, during which the conditions of the flight as to instrument temperature and rate of change of air pressure are reproduced. The lowest pressure indicated by the barograph is measured by a mercurial barometer of the altitude type, or, if beyond the range of the barometer, by means of a mercurial manometer and cathetometer. The air pressure indicated by the barograph at the time of take-off is also determined, and—when such data are available—is compared with the air pressure at the ground level measured by mercurial barometer by the Weather Bureau. This furnishes a valuable check upon the trustworthiness of the barograph.

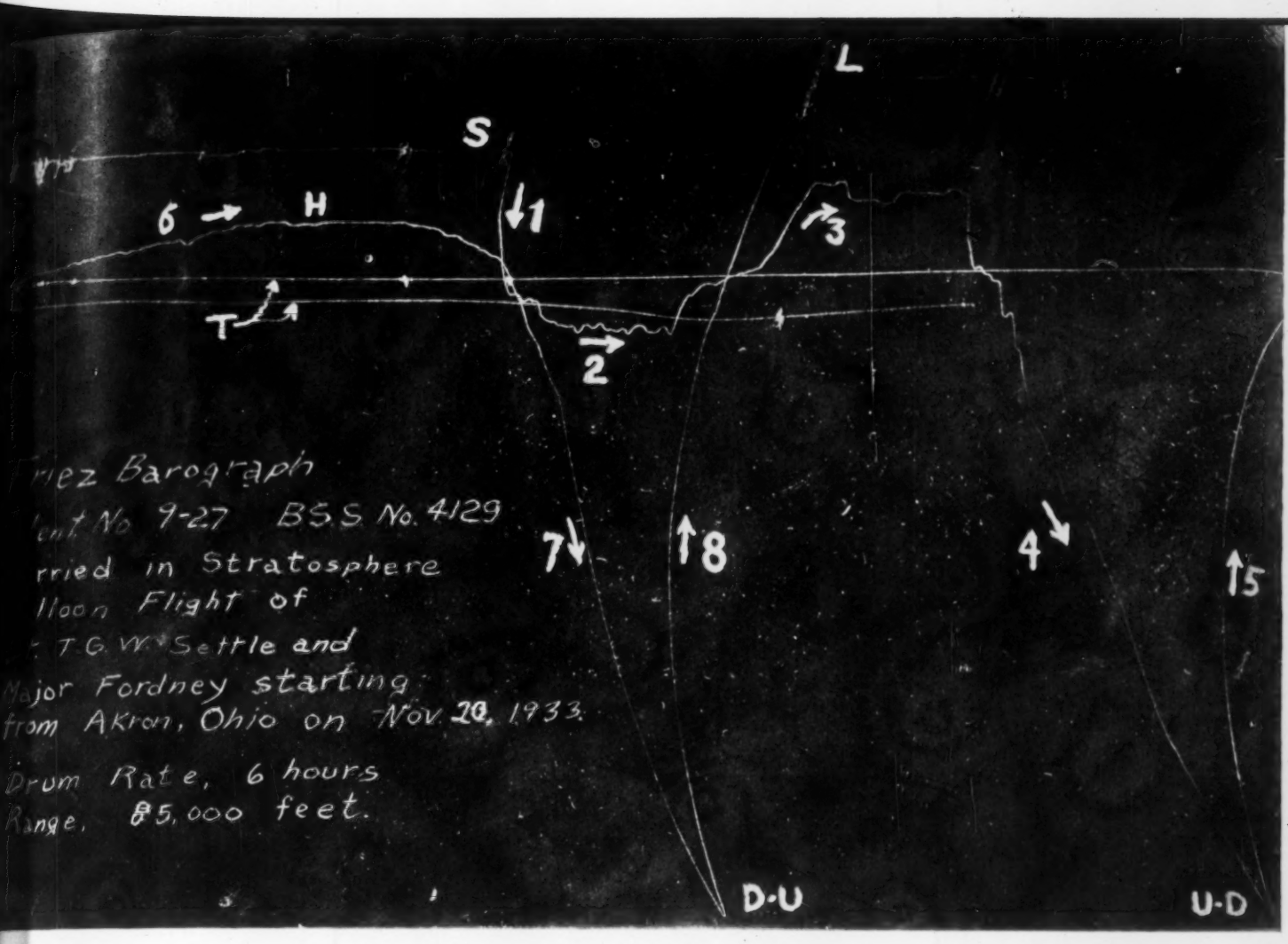
Details of record-breaking flights, and of those otherwise of interest, are given in Tables II, III, IV and V.

TABLE I—STANDARD ATMOSPHERE
ALTITUDE-PRESSURE TABLE

Pressure mm.Hg	F.A.I. Feet	U.S. Feet	Difference Feet
760	0	0	0
400	16371	16713	342
300	23071	23566	495
200	32014	32610	596
100	46614	47156	542
90	48802	49362	560
50	61027	61669	642
40	65689	66341	652
30	71726	72365	639
20	.....	80854	.....

*Chief, Aeronautic Instruments Section, National Bureau of Standards, Washington, D. C.

Substance of paper presented at Third Annual Meeting of the Institute of the Aeronautical Sciences, January 29, 1935. Publication approved by the Institute and by the Director of the National Bureau of Standards.



Facsimile of flight trace which—certified by Dr. Brombacher—constitutes proof of the present world record: the barograph chart of the Settle-Fordney "stratosphere hop" on November 20, 1933. In this historic flight trace S indicates the start of the air pressure record. Following the arrows in numerical order leads to H—the record at the highest altitude—and then to L—the point indicating the landing. The barograph being of the double-traverse type, its trace changes from "up" to "down" at a pressure corresponding to about four miles, and reverses again on passing this point during the descent. The trace made by the instrument temperature recorder is indicated by T.

The F.A.I. in principle has recently adopted for comparison the actual altitude as determined by the barometric formula. The details of making the necessary flight and ground measurements and testing of the instruments have been agreed upon and the new method is to go into effect on July 1, 1935. The following observations will have to be obtained: (*a*) air pressure at highest altitude, (*b*) air pressure at ground level, (*c*) air temperature from ground to highest altitude and (*d*) the elevation above sea level of the point at which the air pressure at the ground is measured. Data (*a*) and (*c*) must be recorded in flight, for which the instruments now commonly used in aerological flights are available. In order to secure accurate data a particular method of installation is required.

TABLE II—AIRPLANE FLIGHTS TO HIGHEST ALTITUDE

Pilot	Country	Date	Lowest Pressure mm.Hg	Corresponding F.A.I. Altitude Feet
J. A. Macready	U. S.	Sept. 28, 1921	178	34563
S. Lecointe	France	Oct. 30, 1923	161.5	36555
J. A. Macready	U. S.	Jan. 29, 1926	146	38704
C. C. Champion	U. S.	July 25, 1927	147.5	38491
St. C. Street and A. W. Stevens	U. S.	Oct. 10, 1928	152	37854[1]
A. Soucek	U. S.	May 8, 1929	143	39140
W. Neuenhofen	Germany	May 25, 1929	126	41794
A. Soucek	U. S.	June 4, 1930	118	43166
C. F. Unwins	England	Sept. 16, 1932	113.5	43976
G. Lemoine	France	Sept. 28, 1933	109	44822
R. Donati	Italy	Apr. 11, 1934	96.5	47352

[1]By barometric formula from pressure and temperature observations, 39606 feet; by camera method, 39250 feet.

The most important feature of this change is the abandonment of a standard atmosphere for comparing the highest altitudes attained by aircraft. It is commonly accepted that a comparison of the performance of airplanes depends on the air pressure and air temperature at the flight level. These two numerical values are used to obtain the performance at an altitude in a standard atmosphere. Various methods of reduction are used upon which considerable difference of opinion prevails. There is, however, general agreement that the true altitude attained by the airplane is in general not a true measure of its high altitude performance. This fact becomes obvious when it is remembered that the actual or absolute altitude depends not only upon the temperature at the

(*Continued on page 103*)

TABLE III—SEAPLANE FLIGHTS TO HIGHEST ALTITUDE

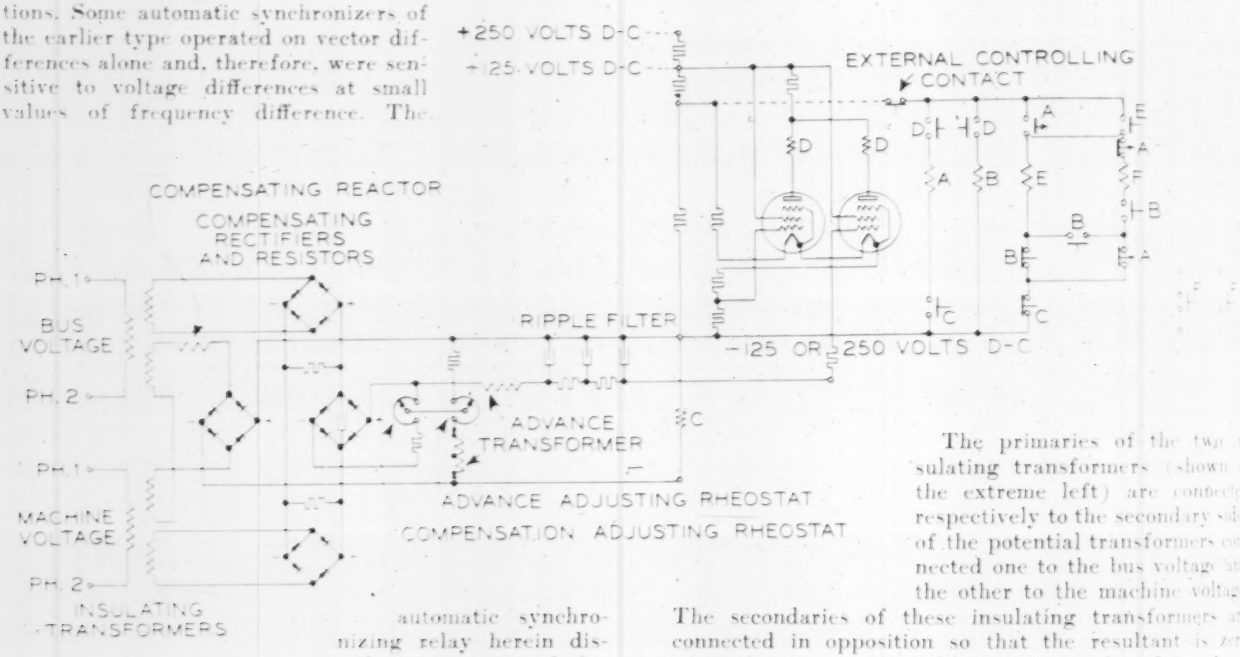
Pilot	Country	Date	Lowest Pressure mm.Hg	Corresponding F.A.I. Altitude Feet
S. Lecointe	France	Mar. 11, 1924	225	29462
V. Demougeot	France	Mar. 28, 1927	215	30479
C. C. Champion	U. S.	July 4, 1927	151	37995
A. Soucek	U. S.	June 4, 1929	147	38560

A New Method of Automatic Synchronizing

By W. A. HOLLAND*

IN both line synchronizing and machine synchronizing, the application of complete automaticity requires a system which is insensitive to differences between source voltages and which has proportional angles of advance. By this latter term is meant the variable angle ahead of zero phase displacement at which the device operates to close the breaker. This angle should be proportional to the rate of motion of the synchroscope pointer, so that a definite time (equal to the breaker closing time) will elapse between the closing indication and the instant of zero phase displacement (exact instant of synchronism).

Some of the earlier methods suffered from errors due to differences of the source voltages; some would give satisfactory operation on gradually decreasing frequency differences but were not well adapted to use with erratic frequency difference such as is found in some low head hydro-electric installations. Some automatic synchronizers of the earlier type operated on vector differences alone and, therefore, were sensitive to voltage differences at small values of frequency difference. The automatic synchronizing relay herein discussed is compensated for voltage differences, and gives the breaker closing indication at an angle that is proportional within 5° for angles in a range of 45° each size of zero phase displacement, and for frequency differences up to one-half of 1% of normal. An element is included to prevent the closing indication being given at greater angles or frequency differences.



This complete system consists of

(1) a network which produces a d.-c. voltage that reverses at the instant that the closing indication should be given;

(2) a thermionic tube amplifier controlled by this voltage; and

(3) a group of interlocking and auxiliary relays.

The operating principles can be understood best by reference to the elementary diagram herewith. Briefly, the network at the left of the center, consisting of: insulating transformers, compensating reactor, resistors, and rectifiers, with an advance transformer, produces two voltages. One of these voltages drops out a checking relay *C* at a definite *angle* in advance of synchronism. The other voltage operates a differential relay *D* at a definite *time* (equal to the breaker closing time) in advance of synchronism. If the relay *C* operates early enough before relay *D*, the significance is that the frequency difference is not excessive, and a main auxiliary relay *F* acts (when *D* operates) to give the breaker closing indication. If relay *D* operates ahead of relay *C*, the significance is that the frequency difference is excessive and an auxiliary relay *E* drops its contacts open so that the breaker closing indication cannot be given.

A compensated amplifier is interposed between relay *D* (which has two coils, one for each tube) and the voltage which controls it. A component of this voltage is provided by a circuit which compensates for differences between the two source voltages so that the definite time of advance of relay *D* is not seriously affected by unbalanced voltages.

The primaries of the two insulating transformers (shown at the extreme left) are connected respectively to the secondary side of the potential transformers connected one to the bus voltage and the other to the machine voltage. The secondaries of these insulating transformers are connected in opposition so that the resultant is zero when the two source voltages are equal and in phase and is a maximum (about 115 volts) when they are 180° out of phase.

This resultant voltage is fed through a compensating reactor to a phasing rectifier. The d.-c. voltage thus obtained is applied directly to the coil of relay *C*.

This d.-c. voltage consists of three components, as follows:

(1) "Phasing" voltage, proportional to phase angle of source voltages.

(2) "Advance" voltage, proportional to frequency difference in the operating zone.

(3) "Compensating" voltage, proportional to the unbalance of source voltages.

The *phasing voltage* is taken from the same rectifier that supplies relay *C*, but is drawn from a potentiometer circuit for purposes of adjustment. This circuit consists of a resistor, the advance adjusting rheostat (see diagram) and the primary of the "advance transformer." The phasing voltage is that measured from the upper tap of the d.-c. voltage down to the tap on the "advance

(Continued on Page 10)

*General Electric Co., Philadelphia, Pa.

Electricity Meters

PART TWO

By PERRY A. BORDEN† and M. F. BEHAR**

12. Multiple-element Meters

In order to make possible the metering of power on all classes of circuits, there are provided watthour meters with a great variety of internal combinations and connections. The three-wire meter has already been mentioned under the head of commutating meters. It is among meters for polyphase alternating current systems, however, that the combining of elements has been carried to the greatest extent. Under Blondel's law, that a polyphase circuit of n conductors may be completely metered by an instrument having $n - 1$ current coils, the two-element meter is universally used for three-wire three-phase circuits, its two elements being mounted on a common spindle, as in Fig. 42-20. Here each element includes the essentials of a complete meter, the motor elements and the brake magnets being practically identical with those used in the single-element meters described above. The two disks rotating

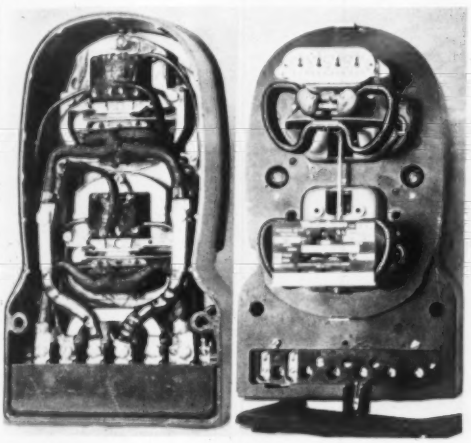


Fig. 42-20 (Westinghouse)

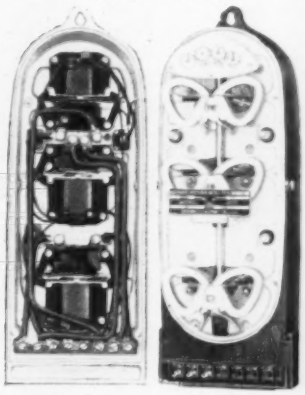


Fig. 42-21 (GE)

together on a common shaft drive a single register, so that the registration represents the summation of the watt values measured in the two elements. In the metering of four-wire loads, conditions are sometimes such as to render desirable the use of a three-element watthour meter rather than an interconnection of current transformers or a two-element meter, as discussed in a previous article.* Such a three-element meter is shown in Fig. 42-21, the three disks being mounted on a long vertical shaft. This type of meter, while necessarily somewhat more fragile than the two-element form, renders possible a high degree of accuracy in metering loads where both current and potential may be unbalanced.

An early form of induction meter made by the General Electric Company, known as the "Thomson High Torque" meter, was built in a polyphase form having two driving elements, as well as the drag magnets, acting on a single disk. This compact form of meter was superseded by the conventional type having two disks on a single shaft. The single-disk form, however, is produced in England by the Ferranti Company, and is available not only in a two-element type but in a model having three independent driving elements, as well as the drag magnets, acting on a single disk. A plan view of this meter is shown in Fig. 42-22. The use of a composite disk with a center portion of glass and outer rim of aluminum makes it possible to have all the elements acting on the one disk, and at the same time minimize the interference among elements.

In those meters where a single rotating member is driven by the joint action of two or more motor elements failure of one of the driving elements might

Instruments, June 1934, page 121. Figs. 34-27 and 34-28 and explanatory material.

*Fourteenth chapter (XLII) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. A complete chapter of this new handbook is published in each issue of *Instruments* throughout 1934 and 1935. Each chapter is subjected to a final revision, and then set in type, shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright. To be issued in book form on or about Jan. 1, 1936.

†Member A.I.E.E. **Editor, *Instruments*

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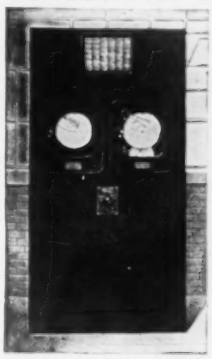

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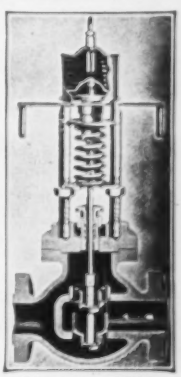

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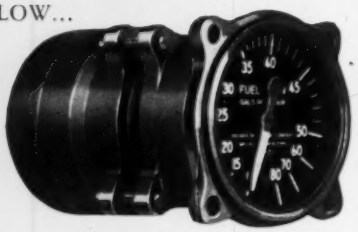

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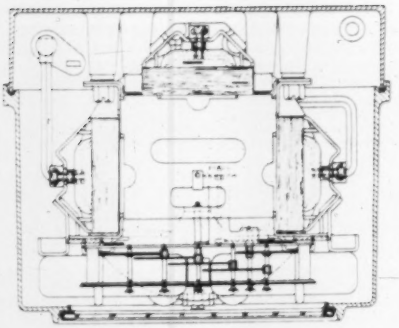

Fig. 42-22

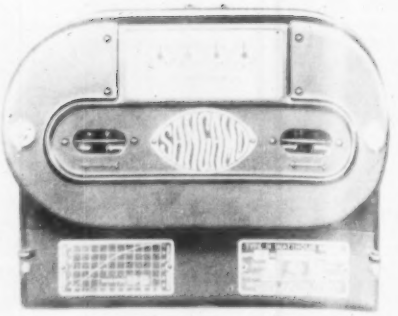

Fig. 42-23

not be apparent on inspection, with the result that the meter would continue to operate and would give a registration for whose error it would be difficult to provide correction. Experience has shown that the only part of an induction meter which is in any way likely to fail in service is the potential system; and this may give out because of either an open circuit in the fine wire winding or of trouble in the voltage transformers. With this in view several manufacturers equip their polyphase meters with a signaling device to provide a positive indication of failure of the potential coil. In some forms each of the potential systems carries a small secondary winding which energizes a miniature lamp distinctly visible from the outside of the meter; and so long as this lamp is burning it is known that the corresponding potential coil is functioning normally. In other makes of meters a magnetic vane or "flag" swings in the potential field; and failure of this field produces a distinctly visible indication.

The Sangamo horizontal polyphase meter, Fig. 42-23 combines two single-phase elements side-by-side in a single case, the algebraic sum of their registrations being obtained by a differential train interposed between the independent disks and the register. This type of meter is inherently free of some of the errors experienced in single-shaft polyphase meters, and the independent action of the elements facilitates accurate adjustment. When installed on balanced polyphase circuits the power factor of the load may be determined at any time by comparing the speeds of the disks and applying the formula or curves in the July 1934 article of this series. As a matter of convenience, the makers of this type of meter provide a copy of a power factor curve on the cover of the terminal chamber. A similar combination of two-wire meter elements is used for measurement on direct-current and single-phase three-wire circuits.

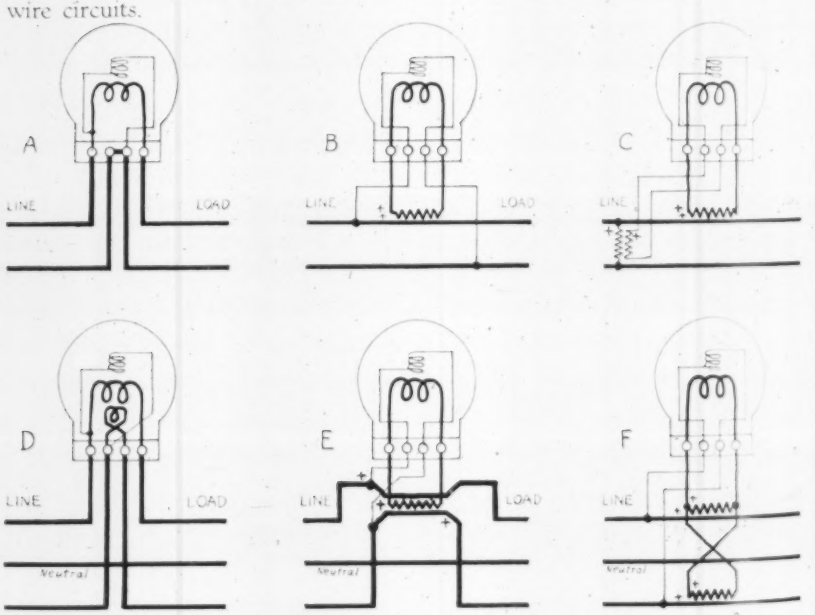

Fig. 42-24. Standard Connections, Single-phase meters.

A, B, C—*Single-phase, 2-wire circuits, 2-wire meters:* (A) Standard connection for meters up to 50 amperes and 575 volts; (B) Current transformer for >50 amp., 115 to 575 volts; (C) Current and voltage transformers for both >50 amp. & >575 volts.

D, E, F—*Single-phase, 3-wire circuits:* (D) Standard connection for 3-wire meters up to 50 amperes, 115-230 volts; (E) 5-ampere, 230-volt, 2-wire meter used with a 3-wire current transformer for 50 to 400 amp., 115-230 volts; (F) 5-ampere, 230-volt, 2-wire meter with two 2-wire current transformers for >400 amp., 115-230 volts.

13. Meter Connections—D.-C. and Single-phase A.-C.

The connections of watthour meters to the circuits under measurement are essentially the same as those of wattmeters, and practically all the wattmeter diagrams shown in the June 1934 article may be applied. Indicating and recording wattmeters, however, are largely supplied in low current ratings, and for loads beyond their capacities are used with shunts or instrument transformers, as the case may be. In the design of watthour meters, on the other hand, every effort is made to simplify the external wiring; and the large number of meters made justifies the cost of their standardization in a wide variety of self-connected ratings. Most manufacturers are prepared to furnish in their standard self-connected lines meters having a.-c. ratings as high as 300 amperes and 600 volts. For d.-c. service, meters rated as high as 1,500 volts (including external resistor) and 6,000 amperes may be obtained.

Coöperation among manufacturers, utilities and supervisory bodies has resulted in a high degree of standardization in terminal arrangements, so that the diagrams shown in Fig. 42-24 may be taken as typical of practically all modern American makes of single-phase watthour meters.

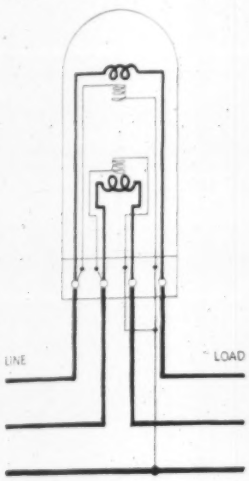

Fig. 42-26. Two-phase or three-phase, three-wire, self-contained.

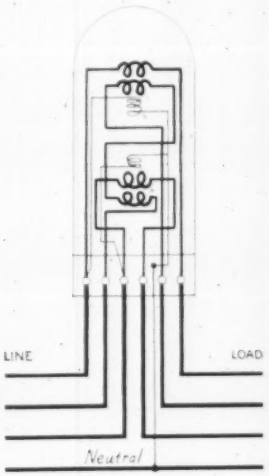

Fig. 42-27. Four-wire, three-phase, two-element, self-contained.

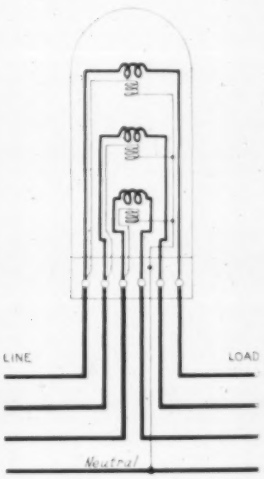

Fig. 42-28. Four-wire, three-phase, three-element, self-contained.

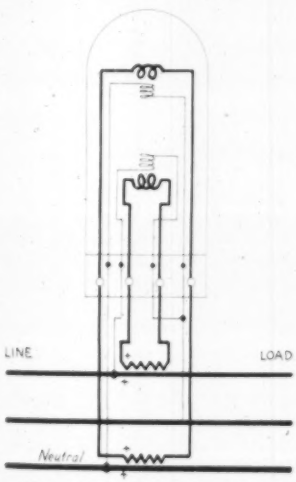

Fig. 42-29. Two-phase or three-phase, three-wire, with current transformers.

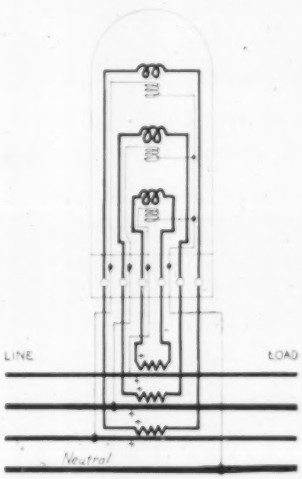

Fig. 42-30. Four-wire, three-phase, three-element, with current transformers.

14. Polyphase Connections

The most common connections of polyphase watthour meters are shown in Figs. 43-26 to 33. A large proportion of actual metering problems is met with this group of connection, leaving but a few where special wiring is required. One type of load requiring special attention is that in which a single-phase three-wire system, generally for lighting purposes, is derived from a mid-tap on one of a group of transformers connected in delta for supplying a three-phase power load. It might be thought that such a load, if non-inductive, would be correctly metered together with the polyphase load if it were arranged that

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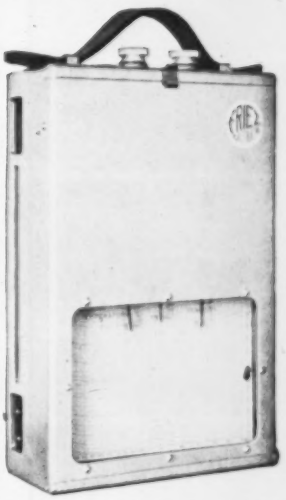

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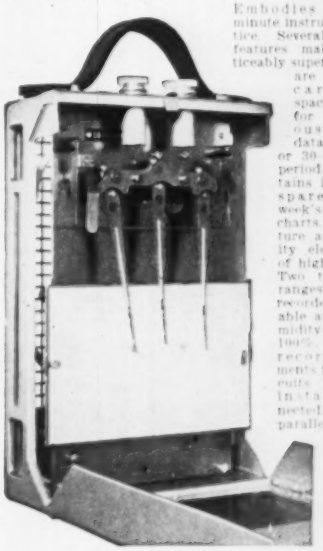

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the tap be taken from the transformer between the phases in which the meter current coils are connected. If the phase-angle between the voltage on the meter and the single-phase current through its coils were exactly 60 degrees, such a measurement would be practicable; but the small discrepancy which may exist between the ideal and the actual conditions will be magnified and may introduce large errors in the measurement of the single-phase component of the load, even were this purely non-inductive; and with an inductive load on the single-phase circuit the error will increase rapidly, making such a method of metering prohibitive.

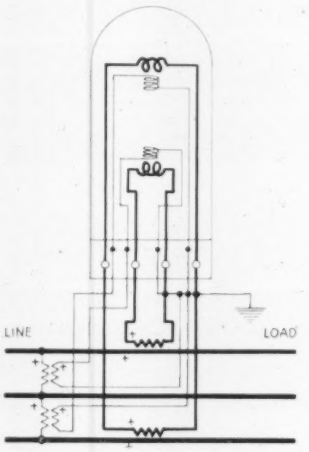

Fig. 42-31. Two-phase or three-phase, three-wire, with current and voltage transformers.

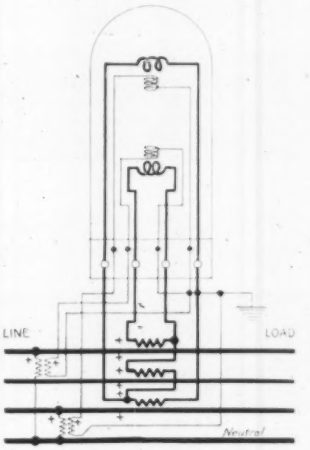

Fig. 42-32. Four-wire, three-phase, two-element, with current and voltage transformers.

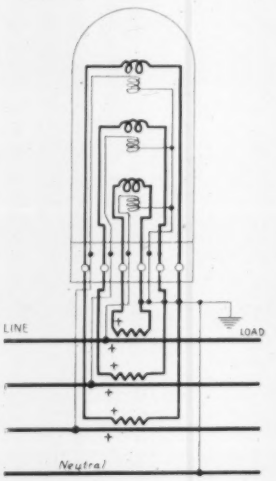

Fig. 42-33. Four-wire, three-phase, three-element, with current and voltage transformers.

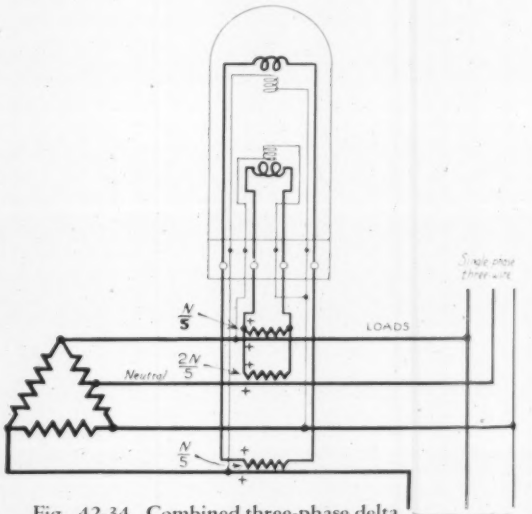

Fig. 42-34. Combined three-phase delta and single-phase 3-wire load metered on two-element meter with current transformers. (Note: Transformer in neutral must have ratio double that of transformers in outside wires.)

There have been proposed a number of methods by which a single-phase load may be included in the total obtainedy on a standard type of meter, or on a meter having its windings modified within practical limits. One of these, developed by G. F. Drewry[1] is shown in Fig. 42-34. This method may be extended to a system in which two single-phase loads can be included in the total, by the addition of current transformers similarly connected in the additional neutral. Additional methods of accomplishing this are cited in the references.[2, 3, 4, 5]

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[1] U. S. Patent 1,688,858, G. F. Drewry, Oct. 23, 1928.
[2] P.C.E.A. Meter Committee Report, *Electrical West*, May 15, 1928, page 463.
[3] P. A. Borden, *Electrical Review* (Chicago), Nov. 27, 1920, page 860.
[4] H. W. King, *Electrical World*, Oct. 25, 1930, page 774.
[5] H. A. Clouse. (To be published in an early issue of *Instruments*.)

METERING FOR SPECIAL RATE STRUCTURES

The subject of electricity meters, as thus far discussed, deals solely with the metering of energy as a tangible entity comparable to weight of fuel or to any other commodity which may be bought and sold. In commercial transactions involving electrical energy, however, a number of factors make *energy consumption* but one of several magnitudes which must be taken into consideration in order to obtain an equitable measure of costs and values. Some of these modifying factors involve the relationship of electrical loads to *time* — both in the sense of time-of-day and of the period in which power is consumed: The measurement of these, generally requiring *mechanical* accessories to standard metering elements, will be fully treated in the next article.

Other modifying factors may be said to inhere in electrical power as such, and may be taken cognizance of by the introduction of electrical or magnetic modifications in the metering equipment. In this class we find power factor and its associated magnitudes, volt-amperes and reactive volt-amperes — magnitudes characterizing alternating-current circuits only, but having an important bearing on the costs of supplying electricity to consumers. Since the metering of other than the *active* component (watts) is usually accomplished by modifications in the electromagnetic systems and is associated with electrical and magnetic characteristics of the meters, reactive volt-ampere-hour meters and volt-ampere-hour meters will be treated in this article.

15. Reactive Volt-ampere-hour Meters

Metering reactive volt-ampere-hours is a practice which has attained a considerable degree of importance, as providing a measure of the magnetizing component used in inductive equipment, integrated over a period of time, so that a consumer of power may be charged with his share of this element of the transmitted power. There are several methods of reactive metering,* all based primarily on the shifting of the phase position of the potential flux in a wattmeter type of element. A watthour meter of the induction type may be used, and the voltage applied to the potential coil displaced in phase by an angle of 90 degrees (see July 1934 article: Fig. 35-9 on page 142) so that the registration will become a measure of the volt-ampere-hours. Quadrature voltages thus derived from a polyphase network are subject to error under conditions of voltage unbalance. A more accurate method of shifting the phase of the potential flux is to combine a capacitance and an inductance with the potential circuit of the meter, thereby shifting the flux in relation to the line voltage. This method is sensitive to frequency changes, but on modern systems these are negligible as compared with variations in voltage balance.

In the same manner as reactive volt-ampere readings may be combined with wattmeter readings to obtain power factor, the registration of a reactive volt-ampere-hour meter over a given interval of time may be combined with that of a watthour meter over the same interval to obtain "average power factor." Since the relative values of active and reactive components will not be likely to vary exactly as their actual values, the result of such a computation is not in the strict sense of the term an *average power facor*. In other words, it is not a mean of all the successive instantaneous power factors. For billing purposes, however, it is generally accepted as suitable for the establishment of charges based on "power factor clauses" in contracts.

"Power factor clauses" are included in contracts in order to charge customers for magnetizing current which they draw from the system. Magnetizing current being drawn from the system at lagging power factor, and being supplied to the system at leading power factor, an integration of reactive volt-ampere-hours is an algebraic sum of all momentary values, both positive and negative. A reactive volt-ampere *recorder* with zero-center charts will produce records made up of positive and negative areas. A reactive volt-ampere-hour *meter*, therefore, should "run both ways": its register should advance on lagging power factor and retrogress on leading power factor, in order that its periodic readings should be true integrations. Reactive meters used for billing purposes, however, are usually fitted with a ratchet to prevent negative rotation, so that a customer who installs and operates equipment which supplies magnetizing current to the system is not credited with his contributions, it being argued that whereas the customer is likely to draw magnetizing current from the system at a time when it must be supplied by the public utility, any magnetizing component he may be able to return to the system (by operating at a leading power factor) is likely to be available only at a time when that component is not required and would disturb the stability of system operation. Whatever the technical justification of such one-way meters, their use should be explicitly stated in contracts embodying a "power factor clause."

*For a detailed discussion see Chapter XIII of Knowlton's "Electric Power Metering" (McGraw-Hill, 1934).

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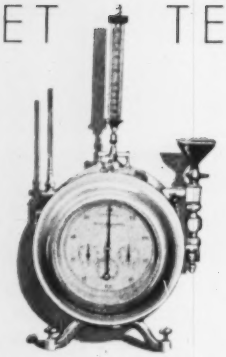

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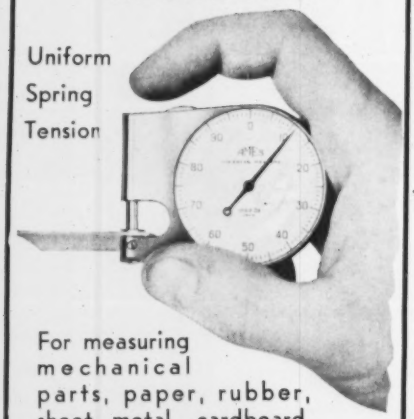

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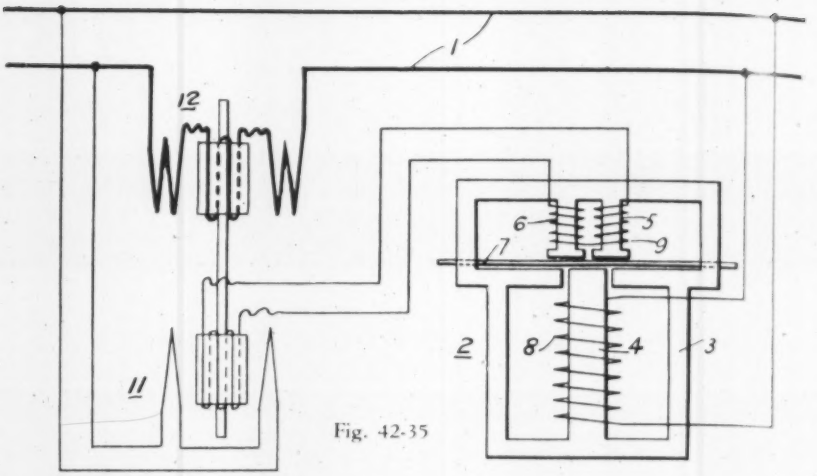

Fig. 42-35

16. Volt-ampere-hour Meters

The metering of volt-ampere-hours presents problems not encountered in the integration of the active or the reactive component. The ideal volt-ampere-hour meter is the equivalent of a watthour meter in which the flux relationships between current and potential elements are maintained as though the load current and voltage were at a power factor of 100 percent. This demands some method of maintaining these fluxes proportional to the respective magnitudes which they represent and at the same time in a fixed relationship as the phase-angle between current and voltage changes with variations in the power factor of the load.

One of the simplest of such devices, developed by Dorfman* (Westinghouse), is shown diagrammatically in Fig. 42-35. An alternating-current circuit 1 has connected thereto a meter 2, having the usual construction of a watthour meter and comprising a magnetic circuit 3 with poles 4, 5 and 6 and a disk 7 free to rotate in the air gap. The potential winding 8 is directly excited from the line. The current winding 9, instead of being connected in series with the line, is supplied from the secondary of a small induction-type regulator 11, the primary winding of which is connected across the line. A small "torque motor" or rotary magnet 12 is connected in series with the line, so that its rotor, and therefore that of the regulator 11, will be positioned in accordance with the intensity of the line current. Hence the secondary voltage of the regulator will be proportional the current in the line but in fixed phase-relation to the voltage of the circuit. Consequently the current winding of the meter 2 will be traversed by a current which is at all times proportional to the current traversing the circuit but at a fixed phase relation to the voltage. Hence the torque on the disk will be in direct proportion to the product of the voltage and the current in the circuit; and if opposed by the conventional system of magnetic damping will cause the meter to operate at a speed representative of the volt-amperes.

A number of other such devices have been developed for the direct metering of volt-amperes on a theoretically true basis; but their cost relative to that of the conventional type of meter has precluded their extensive production; and the metering of volt-amperes is commonly made a matter of compromise or approximation.

It has already been shown that "average power factor" of an electrical load, as determined from the registrations of a watthour meter and a reactive meter does not of necessity represent the mean of all the instantaneous values of power factor during the time interval under consideration. For similar reasons the square root of the sum of the squares of the registrations does not necessarily represent the true value of volt-ampere-hours. As will be pointed out in a subsequent article, the principal object to be attained in volt-ampere metering rests in the determination of maximum demand; and for this reason volt-ampere-hour meters, except as measuring units in demand meters, are used comparatively little. Hence the treatment accorded volt-ampere metering in this article will be confined to types and principles from which an integration of volt-amperes may readily be derived, those suited only to recording or to demand determination being treated in the section dealing with such measurements.

A true measurement of volt-amperes with an element of the wattmeter type (and of volt-ampere-hours with an element of the watthour meter type) requires that one or other of the fluxes be displaced from its normal phase position corresponding to unity power factor by an angle corresponding to the

*U. S. Patent 1,578,501, Leo Dorfman, March 30, 1926.

power factor of the load. However, the error in measurement as the flux swings through a considerable angle about its ideal position is relatively small. This will be made clear by reference to Fig. 42-36, wherein the vector **I** represents a current lagging a voltage **E** by an angle of 53.13 degrees, which corresponds to a power factor of 60 percent. Now, if the voltage applied to the potential circuit of a wattmeter carrying these magnitudes be rotated through an angle of 53.13°, bringing it into phase with the current, the reading of the instrument will then be volt-amperes, so long as the power factor of the load remains 60%. The same result will of course be accomplished if the potential flux be displaced in relation to the applied voltage. Further, suppose the current swings in phase position anywhere between the positions **I'** and **I''**, the reading of the instrument represented in the diagram by the projection of the current vector upon the voltage vector, will not depart from the reading at 60% power factor by an amount greater than that represented by the small distance ***a***. With a permissible error of 2%, the angle between **I** and either of the extreme positions shown can be as great as 11.5°. This means that in the measurement of volt-amperes the total angular variation in the position of the current vector can be as great as 23° before the error of measurement exceeds 2%. The corresponding variation in power would be represented by the range from ***b*** to ***c***. In other words, a wattmeter having its voltage flux displaced by an angle corresponding to a 60% power factor will measure volt-amperes with an error not exceeding 2% with a power factor varying from 42.9% to 74.7%.

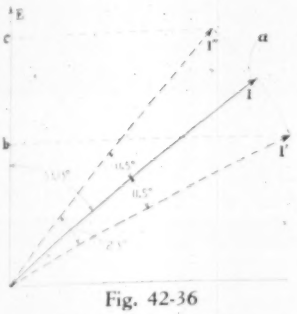

Fig. 42-36

Phase-shifting transformers are available, providing a secondary voltage equal in value to the applied voltage but shifted through a definite phase-angle corresponding to some selected power factor value; and wattmeters or watt-hour meters used in conjunction with these provide readings of volt-amperes or of volt-ampere-hours, as the case may be (within the above-mentioned limits of error). In general these transformers have several sets of taps, so that there may be selected a phase position most nearly corresponding to prevailing load conditions, as determined by a preliminary test. Measurements obtained with such a transformer are shown for two taps, 60% and 80%, in Fig. 42-37. For instance, if a phase shift corresponding to 60% power factor, as mentioned above, be applied to the voltage on a given wattmeter, this wattmeter will then read volt-amperes with an error not exceeding 1% so long as the power factor remains anywhere between 0.481 and 0.707; and the error will not exceed 2% for any power factor between 0.429 and 0.747. If the 80% tap be used, the error will not exceed 1% for any power factor between 0.708 and 0.877, and will not exceed 2% for any power factor between 0.665 and 0.903. An interesting point in regard to this method of measuring volt-amperes or volt-ampere-hours as a basis of establishing billing charges is that such error as inherently develops with divergence of the actual from the estimated power factor is always in the customer's favor—the safe direction. If a meter could

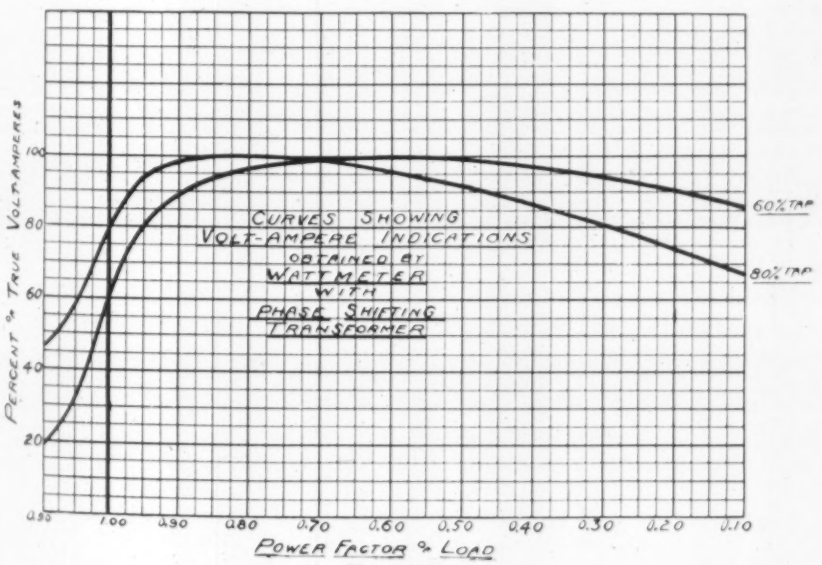

Fig. 42-37

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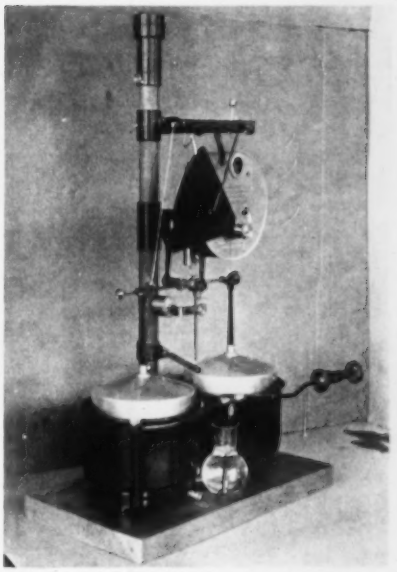

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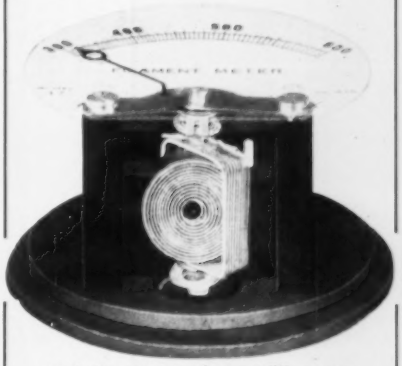

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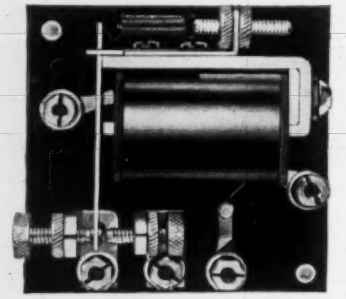

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be provided with a considerable number of phase shifting devices, and these automatically switched to that most nearly corresponding to the then value of power factor, there would be obtained a measure of volt-ampere-hours accurate through a wide range. Such a switching arrangement, however, would not be practicable, and the nearest development to this which has yet appeared is found in a type produced to a limited extent by the General Electric Co. This meter comprises three single-phase elements, in which each potential system is "lagged" to correspond to a predetermined power factor, the usually selected values being 60%, 84% and 98%. The three elements engage a single register through ratchets, so that the element running at the highest speed operates the register. By adjusting each element to be 1% high at its "lagged" phase angle, this meter can be made to give a measure of volt-ampere-hours with an error not greater than 1% for any power factor value between 40 and 100 percent. For volt-ampere-hour measurement on polyphase loads it is necessary to use a separate meter for each conductor of the system, connections being made according to the "three-wattmeter" method.

A volt-ampere-hour meter bearing a certain similarity to the above is the "Trivector," made by Landis & Gyr of Switzerland. This meter incorporates in one case a watthour meter and a reactive meter, each having its own register. The mechanical train by which the computation of volt-ampere-hours is effected is shown in Figs. 42-38 and -39. Spindles 10 and 11 are the rotor shafts of the watthour meter and of the reactive meter respectively; and these are directly geared to the cyclometer registers 12 and 13, upon which are obtained registrations of watthours and reactive volt-ampere-hours respectively. In addition, each spindle is coupled to a ratchet on the shaft 22 of the cyclometer train 30, so that whichever spindle rotates faster will drive this train. In addition to the trains mentioned, there are driven by the two metering elements the sun-wheels of a group of planetary gearings, so that the planet wheels are given velocities representing combinations of the speeds of the two driving members, taken in different proportions, and therefore corresponding to volt-ampere values at

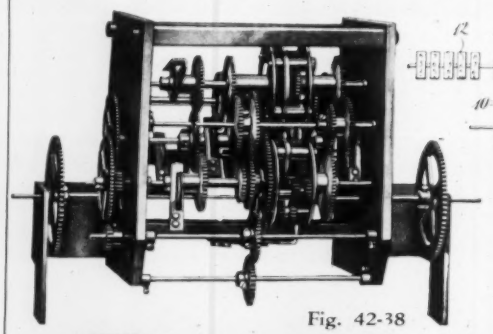

Fig. 42-38

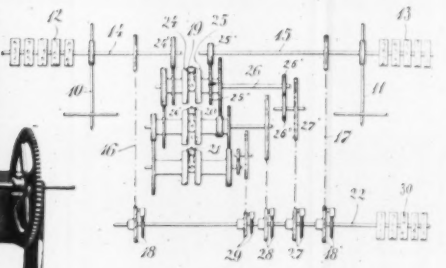

Fig. 42-39

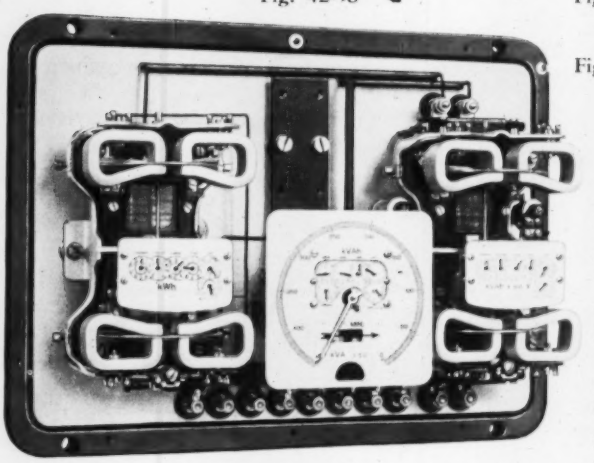

Fig. 42-40

different power factors. Each planet wheel may drive shaft 22 of register 30 through a ratchet wheel, so that the speed of this shaft will be that of the ratchet which is operating faster. By proper selection of gear ratios this meter may be made to register within 1% all values of volt-ampere-hours in a phase angle range of from 0° to 90°; and by the addition of a simple relay device incorporated in the meter the range is extended from zero lagging, through unity, to zero leading. The meter may also be fitted with a double register so that reactive component values for leading and lagging power factors may be registered separately. Fig. 42-40 shows, for example, a three-phase three-wire "Trivector" for unbalanced loads, consisting of a watthour meter section (left), a volt-ampere-hour section with maximum demand indicator (middle) and a reactive component section (right).

INSPECTION and TESTING

FINAL OR "CERTIFICATION" INSPECTION OF ETCHED-STEM THERMOMETERS

(Courtesy Taylor Instrument Companies)

Checking for Phase Rotation in Reactive Metering

By CHARLES H. THAYER*

IN measuring the reactive component with a watthour meter, it is necessary to shift the potentials 90° from their normal position. This makes possible two potential connections. With one connection the meter would run in a positive direction under lagging power factor conditions; with the other it would run in a positive direction under leading power factor conditions. If there is a load on the meter and we have knowledge of it to the extent of whether it leads or lags, no trouble will be had in properly connecting the meter. We should, however, have some method of determining whether the meter is correctly connected without having a load on it. The method used by the writer for a number of years may be of interest.

Fig. 1 shows two meters connected to a two phase, three wire circuit. It is assumed that meter *A*, which measures the active component, is correctly connected. Meter *B* is connected to measure the reactive component. The potentials in the installation shown are connected to a four-pole double-throw switch so that in the down position the meter may be tested with normal potential connections to it (we assume that the meter is correctly connected in this position). In the upper position the potentials to the meter are 90° from the normal position. We will assume that meter *B* is supposed to run in a positive direction with a lagging power factor load. The potential to each element should, therefore, lag from its normal position by 90° so that as the current lags it will come nearer in phase with this potential, and the reading of the meter will increase as the current lags.

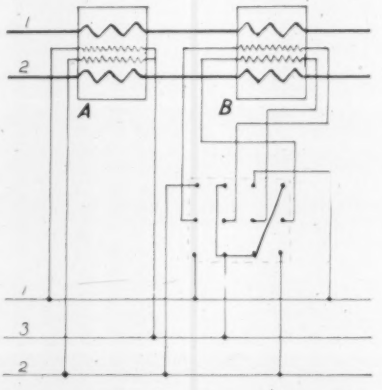

Fig. 1. 2-phase 3-wire circuit. Watthour meter *B*, connected to 4-pole double-throw switch, will indicate reactive kwh on up position. Down position is for testing.

The necessary equipment to determine this consists of a rotating standard, a phantom load and a small coil of annunciator wire. The writer has a test plug connected to the coil of annunciator wire which may be plugged into a test jack on the load box in series with the current circuit. The opening in the coil is large enough so that a wrench or a pair of pliers may be inserted in it.

The current circuit of the standard should be connected in series with the current circuit of the load box. A set of potential wires should be connected to the potential circuit of the standard and another set of potential wires should be connected to the potential circuit of the load box. Each set of potential leads should have a red and black terminal for easy identification. The four-pole switch should be in the test position. Connect the potential leads from the standard to a pair of potential terminals on the test side of the switch. The potential leads from the load box are connected to the blades of the switch which are in contact with these potential terminals. The two red leads should be connected to one side and the two black leads to the other. Close a switch on the load box so that three or four amperes flow through the standard and if necessary reverse the current connections to standard so that it moves in a positive direction. Now with the potential connections as they were, throw the four-pole switch to the operating position. The standard should now stand still because the current is 90° out of phase with its potential. See Fig. 2. 1-3 is the potential to the standard and if the potential to the load box lags 90° it will take the position 2-3. In order to determine whether the potential to the load box does lag or not, we plug in our coil and note the direction of rotation of the standard. If it does lag it will cause the current from the load box, supplied by potential 2-3, to lag more than 90° as shown by the dotted line in Fig. 2, and the standard will run in a negative direction, indicating that this element of the meter was correctly connected. If the potential to the load box 2-3 leads the potential 1-3 to the standard as shown by Fig. 3, the current from the load box, supplied by potential 2-3, would take the position shown by the dotted line after the coil was plugged in circuit, and the standard would run in a positive direction, indicating that the meter was not correctly connected to measure lagging power factor conditions. The other element of the meter would be checked in the same manner. To measure the reactive component on a *three-phase circuit* it is necessary to use transformers to bring about the 90° condition. However, the checking of the connections to the meter is done in the same manner as for the two-phase meter.

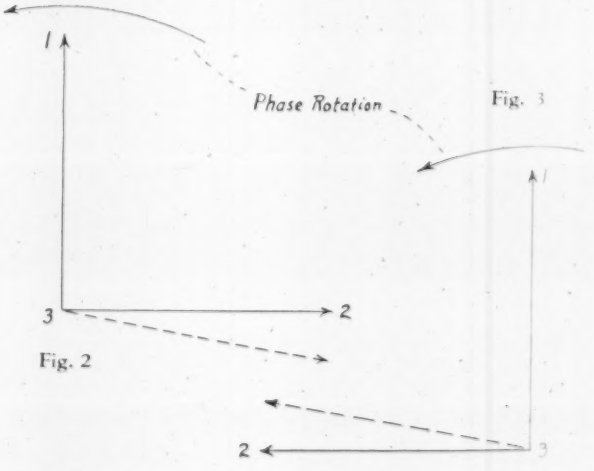

Fig. 2

Fig. 3

This same method can be used to check Lincoln demand meters in connection with phasing transformers.

*Electrical test and calibration specialist, Ashland, Mass.

Materials Testing Machines

An Account of Their Development, with Special Reference to the Tension-Compression-Transverse Group

By C. H. GIBBONS*

PART SIX

A. H. Emery secured his United States Letters Patent on the designs of the United States Testing Machine June 5, 1883, and the same year he disposed of them to Yale and Towne of Stamford, Conn. In all, eight Emery type machines and one 70,000-lb. hydraulic support calibration machine (for Sibley College, Cornell University) were built by them. The capacities ranged from 70,000 to 300,000 lbs.—one each of the latter going to Cambria Iron Co., Johnstown, Pa., and to Bethlehem Iron Co., Bethlehem, Pa.[67] One of 150,000-lb. capacity was exported to the Royal Laboratory of Vienna. In general, these were vertical machines (Fig. 31).[64]

Because testing machines did not fit well into the line of Yale and Towne, they sold the patents, in 1889, to William Sellers and Company, Philadelphia, who built numerous Emery type machines (mostly horizontal), the last being dated 1905 and being exported to the Polytechnic Institute, St. Petersburg, Russia. Several traction dynamometers, weighing beams and calibrating devices employing the Emery principle, were built up to 1917, but no other testing machines.

The largest of the testing machines built by Sellers was a 300,000-lb. universal for the Massachusetts Institute of Technology in 1892. This machine accommodated specimens in tension up to 13 feet length and compression specimens up to 18 feet length. Clear space between 7″ diameter screws was 39″. It was lately (1931) removed from the laboratory to make room for a more modern vertical machine of 300,000-lb. capacity and one using the same basic principles as those of the one removed.

It is not generally known that the Fairbanks Morse & Co., Chicago, was actively engaged in the manufacture of testing machines through the eighth and ninth decades of the last century. It seems that, in general, these testing machines were adaptations of the platform scales built by this company,[68] and were built in sizes from 100,000 to 1,000,000-lbs. capacity. There was one unique feature, however, which justifies a notation. The scale beam was double with a heavy poise on the upper branch. The lower branch had a lighter poise which moved under the force of a weight to which the poise was attached by a cord. The motion of the lighter poise was then controlled by an escapement operated by the rise and fall of the scale beam.[68]

Another machine which deserves mention because of the single unique feature, was the 50-ton single lever testing machine at St. Chaumond, France. The lever consisted of two I-beams, 12″ deep, 14 feet long, side by side with the main fulcrum between them. The poise traveled along these beams. The unique feature was the use of a wedge driven by a worm wheel and screw for counteraction of strain.[69]

About 1886, Charles Kellogg designed for the Union Bridge Co. at Athens, Pa., a 600-ton horizontal tension testing machine for specimens up to 40 feet long, having a large hydraulic cylinder, the load being estimated from the hydraulic pressure in the cylinder.[70] The base rails were two riveted girders 42″ deep and 60 feet long. The cylinder was $51\frac{3}{4}$″ diameter bore, open at one end and having an effective stroke of 59″. Hydraulic pressure available had a maximum of 600 lbs. in.^{2} and was measured by a Shaw mercury column and by a Bourdon tube gage. Four $5\frac{3}{8}$″ diameter piston rods were attached to the piston, which had a gland and flax packing. The piston rod glands, also, were packed, but in service were not drawn tight. It was desired that a thin film of water pass at all times during the testing so that piston and piston rod friction would be reduced. Pressure was supplied from a $2\frac{1}{4}$″ by 10″ single acting triplex pump.

A 1200-ton machine of similar construction (but universal)[71] was built at Phoenix Iron Works, Phoenixville, Pa., in 1890.[72] The cylinder was 64.1″ in diameter and the stroke was 72″. There were four $8\frac{1}{2}$″ diameter piston rods and the hydraulic pressure available was 800 lbs. in.^{2}. Flax packing was used both on rods and on piston. Maximum tension specimen was 50 feet center to center of pin-holes (eye-bars) with 30″ diameter of heads $4\frac{1}{2}$″ thick. Mercury gages were used for pressure measurement and a friction recoil device absorbed the energy released at rupture of the specimen.

The accuracy of this machine[73] and of this type of machine[61,64,74] had long been questioned when in 1908 extensive tests were made in comparison with the Emery machine at Watertown.[74] These tests indicated that if, in this case, an allowance be made of 12,000 lbs. for friction *at all loads* the accuracy of the machine was quite good. In other words, the percentage of inaccuracy of load indication decreased rapidly as the load increased.

A similar testing machine of 2,000-ton capacity was constructed by The American Bridge Company, Ambridge, Pa., in 1904.

During the period 1890 to 1907 there are only two large machines that merit attention; *viz.*, the Hoppe and

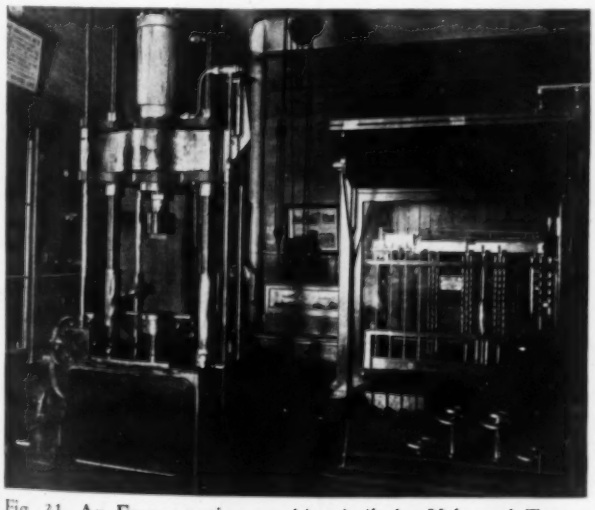

Fig. 31. An Emery testing machine built by Yale and Towne, in 1889, for Columbia University.

*Baldwin Southwark Corp., Philadelphia, Pa.

[67] This latter machine is in service still (1935).

[68] *Journal Franklin Institute*, No. 108, 1879, page 98.

[69] MM. Denizeau & Lechien. Mémorial de l'Artillerie et de la Marine, 1883.

[70] *Railroad & Engineering Journal*, Vol. 61, Feb. 1887, page 71.

[71] *Engineering News*, Vol. 70, 1913, page 537.

[72] *Engineering News*, Vol. 25, Jan. 10, 1891, page 42.

[73] *Engineering News*, Vol. 39, Jan. 13, 1898, pages 27-28.

[74] *Engineering News*, Vol. 62, 1909, pages 377, 386.

that of the Conservatoire des Arts et Métiers. But there was a very important development in the evolution; *viz.*, the introduction by Amsler of the dial for load indication.

The Hoppe testing machine of about 1894 at Charlottenburg, near Berlin[21] had a capacity of 1,100,000 lbs. and handled specimen 49 feet long and up to 31″ square. It was so arranged that either the cylinder or the ram, which was used for load-producing purposes, could be locked to the bed. This feature, in association with an unusual construction of the load connection to the first lever of the weighing system, afforded certain conveniences in operation.

The 300-ton (672,000-lbs.) testing machine built by Joshua Buckton and Co., Ltd., of Leeds, England (1904), for the Conservatoire des Arts et Métiers, Paris,[21] accepted specimens in tension or compression up to 88 feet in length and 39″ square, and also had facilities for transverse testing of large specimens. Load application was by means of an hydraulic cylinder with a pump and accumulator system. The ram was 26″ in diameter and the stroke 84″; the maximum pressure about 1700 lbs. in.$^{-2}$. The ram was of steel, copper plated, and the packing was U-leather. The lever weighing system had a ratio of 600 to 1 and the shortest lever

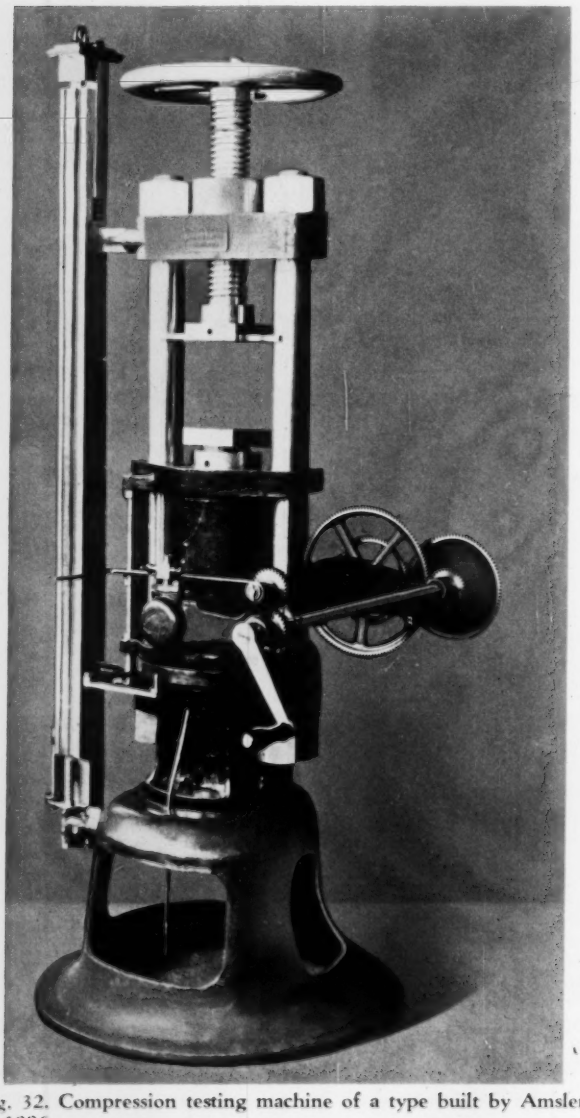

Fig. 32. Compression testing machine of a type built by Amsler in 1886.

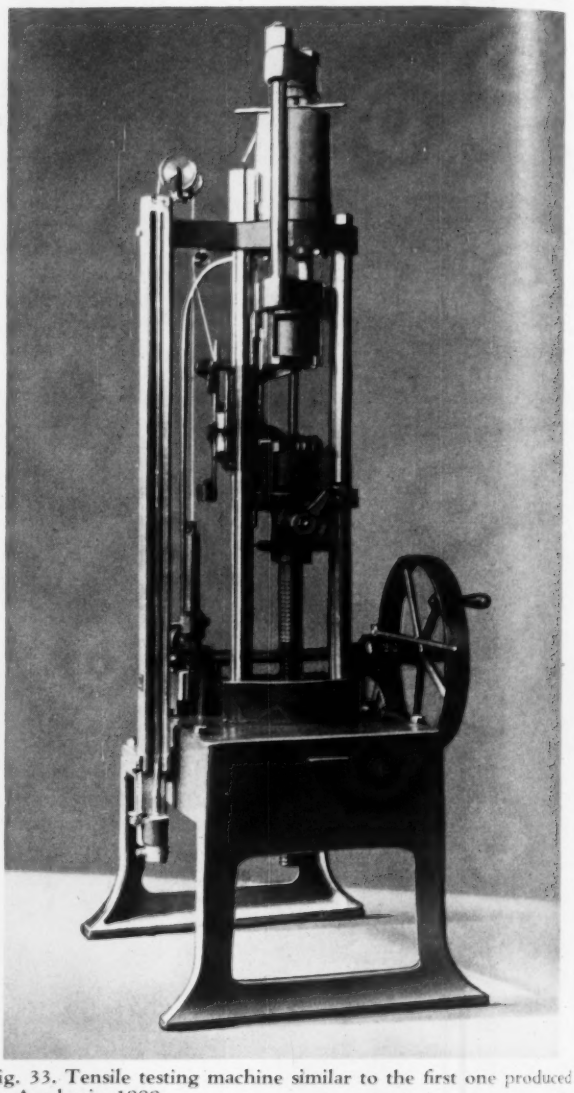

Fig. 33. Tensile testing machine similar to the first one produced by Amsler in 1888.

was 2″. Its features consisted of a moving bed with the weighing levers and the hydraulic cylinder at one end. The cylinder was fixed and the ram movable. It was extremely sensitive as is evidenced by the fact that a 4-lb. change of load at 100 tons was indicated by the weighing system.

About 1904 there was a development in testing machine design which was destined to have a marked influence on the trend of testing machine evolution. This was the introduction by J. Amsler-Laffon & Son, Schaffhouse, Switzerland, of a dial indicator for load indication instead of a manometer, a lever-and-poise, a scale, such as the Emery, etc. It is true that a very early Riehle used a dial gage, but it was soon replaced by a lever and poise. It is true that Bourdon tube gages had been tried, but without a marked success.

A word in passing as to the development of dial indicators may be interesting and of value since today, to be modern, a testing machine must have some device for automatic continuous indication of load. A similar transition took place in the development of our timepieces. Early devices for measuring the passage of time had nothing of this kind and the invention of the clock face and hands made obsolete all the older methods. It is

interesting that a recently popularized form of clock does not have a face but only openings through which may be read directly the time in hours and minutes. It is possible that some such development as this may be the next advance in load indication for testing machines.

The earliest record of a dial indicator—continuous automatic indication of values—on a testing machine is that on a machine of Thomas Dunn in England late in 1865. It is not improbable that Bourdon tube gages, with dials and indicating hands as was the customary construction, had been used before. The decade between 1845 and 1855 had seen an intensive development of the Bourdon tube pressure-indicating gage, no less than four inventors claiming priority of conception of invention, and it is, therefore, highly improbable that this obvious application had been made. In comparison with the lever-and-poise, however, the Bourdon tube pressure indicating gages of that day were grossly inaccurate and no progress was made in their application to testing machines as load indicators.

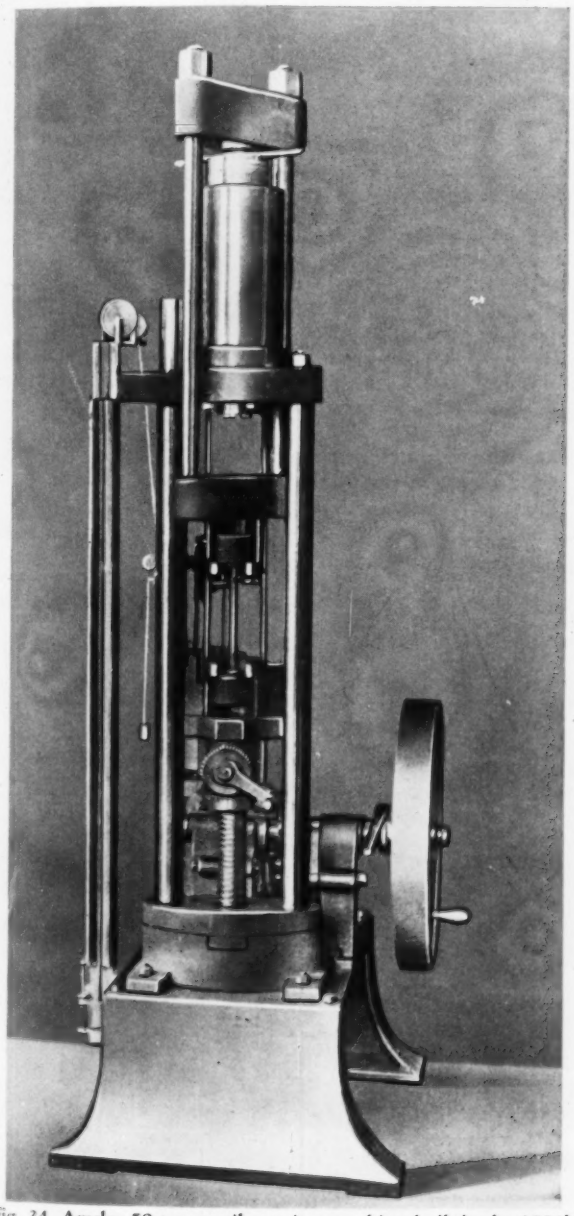

Fig. 34. Amsler 50-ton tensile testing machine built in the 1890's.

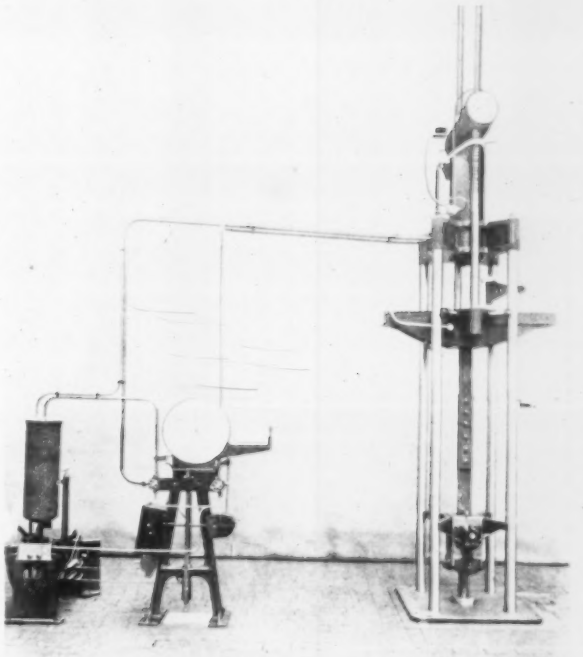

Fig. 35. The first pendulum dynamometer for indicating on a dial the load on the specimen. Built by Amsler in 1904.

A few years later Riehle in the United States applied a dial indicating gage to what was probably the first one to be built by that firm. It seems to have been a dial type spring balance and since Riehle Bros. were scale builders before they turned to testing machines this fact lends weight to the assumption. It was probably not sufficiently accurate, for a testing machine of their manufacture three or four years later reveals that the idea had been discarded insofar as the major weights were concerned, only a relatively small portion of the required load being weighed on a spring balance with linear scale.

A little-known development in this direction was that of A. H. Emery, previously noted as the builder of the famous testing machine at the Watertown Arsenal. He, in 1883, patented a dial-indicator pressure gage based on the use of his famous hydraulic support or capsule and flexure plates in the lever system which magnified the movements of the support to values which were serviceable.

It is surprising to us that this seemingly obvious application of this precision device to a testing machine for the purposes of load indication was not made. It is probable that the development of the art had not yet reached a point where continuous indication was thought of either as necessary or as desirable. So for twenty years there was, apparently, no progress in this direction.

J. Amsler-Laffon & Son was established in 1854 as manufacturers of instruments, M. Amsler being the inventor of the polar and other types of planimeters, of integrators, and of other scientific instruments. Their first testing machine was built in 1886, was for compression only, was of 15-ton capacity, used the hydraulic principle for load production and strain compensation. The ram was carefully ground and used no packing. It incorporated another feature which has long been associated with the Amsler name—that of the rotation of some part of the load producing or load weighing (or both) system to reduce the friction of the ram on the cylinder walls. This idea was not new even in its appli-

cation to testing machines, as Chas. Emery had patented the idea in the United States in 1883, and a mechanism based on the principle had been built and used in 1879 in proving the accuracy of the Emery machine at the Watertown Arsenal. The application was not made practical, however, nor applied currently to testing machines until the development just mentioned.

The hydraulic pump was of the screw type and hand driven. The load-measuring device was a mercury manometer. Fig. 32 is a view of a similar machine.

Amsler's first tensile testing machine was built in 1888 and was of 30-ton capacity. It employed a mechanical application of load and load was measured by a mercury manometer. It was similar to the machine shown on Fig. 33.

Early in the last decade of the 19th century the 50-ton tensile testing machine of Fig. 34, having hydraulic means of load production and hydraulic means of load measurement, was built.

In 1904 the first pendulum dynamometer for measuring and indicating on a dial the load on the specimen was built. The type is that shown in Fig. 35.

As suggested earlier, this idea of using a dial for load indication has spread so widely that today a machine without a dial indicator is hardly modern. One of the world's largest testing machines was recently modernized by the application of dial gages, although the older lever-and-poise system was not removed. The application was made to increase the convenience of the use of the machine.

(To be Continued)

The "True Direction" Aircraft Instrument Question

Discussions of Article by A. M. Dudley in February Issue

To the Editor:

It may be agreed that the true direction compass reported by Mr. Dudley is inoperative. However, it should not be necessary to go beyond well-known engineering principles in explaining why.

The simplified diagram of Fig. 4 shows two coplanar coils on one shaft. Magnetic shielding is indicated, the intention being that only vertical conductors G and H, and horizontal conductor KL should cut flux. Unfortunately, there is no known material which will accomplish such shielding, without distorting the magnetic field so that the desired result is not obtained. The two coils will generate in phase voltages when rotated in the earth's field, though the coil KL may have such a small window that its voltage is nearly zero. Direction of flight should have no effect on the phase angle.

When conductor KL is perpendicular to the line of flight a maximum voltage will be induced, not only in KL but in the other conductors. No net voltage can be indicated, since all conductors between K and L must cut the same flux. There will be a concentration of electrons at the negative end of the conductor, and a concentration of positive particles at the other end. This voltage or concentration is not readily determined.

The passage of the plane through the assumed stationary magnetic field may possibly be determined by means of the principle of the lateral thrust on a current carrying conductor in a magnetic field. A highly charged insulated body would be freely supported within an electrostatic shield. This body should be deflected perpendicularly to the line of flight, just as electrons shot through a magnetic field are deflected.

Another possible method of determining direction of flight without reference to even the magnetic field lies in integrating the acceleration to yield the change of velocity, and integrating the velocity to obtain the change of position. If the position and velocity at any time are known, the position and velocity at any subsequent time can be determined. An accelerometer sensitive enough to determine the accelerations with sufficient accuracy may not be obtainable at the present time, but the method has theoretical possibilities, the theory of relativity to the contrary.

The Foxboro Co. — A. P. Stevens
Foxboro, Mass. — *Research Department*
February 27, 1935

To the Editor:

I have read with interest Mr. Dudley's article and must say that it does not require knowledge of Einsteinian Relativity to point out the fallacy in the proposed instrument. If one concentrates on the lower part of Fig. 1 and assumes the conductor KL to be rotated about a vertical axis through the intersection of KL and $O'C'$ it is apparent that no potential is generated, as Mr. Dudley points out.

Next assume the conductor KL to be translated horizontally (without rotation) along the line $O'C'$. Still no potential generated.

Now rotate and translate at the same time; and try to figure how the combination of two motions—neither of which generates potential—can produce an indication on the voltmeter V.

This "solution" was first sprung on me over a chocolate sundae in Smellie's drug store in Hammondsport, N. Y., in 1913, and it turns up somewhere once or twice a year with deathless persistence.

I am glad to know that *Instruments* is conducting a forum on the "true direction" question and regret that at the present time I am too busy to prepare anything for it.

Morristown, N. J. — Charles H. Colvin
March 22, 1935 — *Colvin Laboratories*

Scale Distribution and Its Effect on Observational Errors

Discussion of Article by R. G. Jewell in March Issue

To the Editor:

The article by Mr. Jewell on Instrument Scale Distribution is of particular interest because this subject, treated at length abroad, has thus far been almost ignored by American writers. It is to be hoped that the article will stimulate discussion and the preparation of other articles on the subject. In default of the complete discussion for which time is not available, I should like to comment on two matters which interested me particularly.

In equation (3) Mr. Jewell has the factor cos $(\gamma+\alpha+D)$, which would be correct for the simple but impractical case in which the area of the moving coil is infinitesimal in comparison with that of the fixed coil. In the practical case, this cosine relation may be closely approximated (as in the Weston Model 310 wattmeters, and some others) by special geometric proportions between fixed and moving coils, these proportions doubtless having been found by the cut-and-try process. A direct solution of such problems has been called hopeless, by a British mathematical physicist, in the present state of mathematics.

The last reference given in the bibliography is that to Bruger's article on an electrodynamic ammeter and voltmeter with uniform scale. Certain readers may feel the lure of this uniformity; and therefore it may be well to call attention to reference No. 19 in the same bibliography, which is to my paper on the accuracy of commercial electrical instruments. In this paper I referred to Bruger's instrument and added what was perhaps too mild a word of caution, that "In general, however, instrument scales should follow the natural law of the instrument (type), if an efficient design is desired." In Bruger's instrument, for example, the fixed coil is bent at an angle such that as the moving coil moves up scale it experiences an actual *retarding* torque from part of the fixed coil, this torque throttling the natural tendency for the deflection to increase as the square of the current. Mr. Jewell has not pointed out this defect of "trick" scale-law instruments. Of course, with some systems having an abundance of deflecting torque, some of it may be sacrificed to obtain a certain form of scale.

National Bureau of Standards, — H. B. Brooks, *Chief,*
Washington, March 25, 1935. — *Electrical Instrument Section.*

HOW ALTITUDE RECORDS ARE CERTIFIED

Continued from page 87

altitude of flight but upon the mean temperature of the air column below the airplane.

In the case of balloons the best performance is measured by the lowest air density reached. The balloon attaining a given lowest air density may not attain the same altitude at one time of year as at another.

Thus it appears preferable to retain the method of comparison utilizing a standard atmosphere. The altitude now necessary to break the unlimited altitude record for either airplanes or balloons is well into the stratosphere, in which the air temperature can be considered constant. *In these cases* the lowest *pressure* attained gives a reasonably accurate index of the performance of either balloons or airplanes.

In the case of records in other categories now at lower altitudes, the method of determining the altitude of airplanes in the standard atmosphere should follow one of the methods of reduction used by aeronautical engineers.

As it is unlikely that general agreement upon the proper method can be obtained, the simplest solution is to retain, as the measure of performance, *the lowest pressure attained, converted to altitude in the standard atmosphere.*

TABLE IV—OPEN-GONDOLA BALLOON FLIGHTS TO HIGHEST ALTITUDE

Pilot	Country	Date	Lowest Pressure mm.Hg	Corresponding F.A.I. Altitude Feet
Suring & Berson	Germany	July 31, 1901	170.5(?)	35424
H. C. Gray	U. S.	Mar. 9, 1927	235	28510
H. C. Gray	U. S.	May 4, 1927	122	42470[1]
H. C. Gray	U. S.	Nov. 4, 1927	122	42470[2]

[1]Not recognized as a record because Capt. Gray jumped from balloon before landing.

[2]Not recognized as a record. Capt. Gray was found dead in the gondola and it was therefore presumed that he did not navigate the balloon to a landing.

TABLE V—STRATOSPHERE BALLOON FLIGHTS

Pilots	Country	Date	Volume of Balloon cu.ft.	Lowest Pressure mm.Hg	Corresponding F.A.I. Altitude Feet
Piccard and Kipfer	Belgium	May 27, 1931	500,000	78	51775
Piccard and Cosyns	Belgium	Aug. 18, 1932	500,000	73	53153
Prokovieff, Birnbaum, and Godounoff	U.S.S.R.	Sept. 30, 1933	860,000	49.50	61237
Settle and Fordney	U. S.	Nov. 20, 1933	600,000	49.5	61237[1]
Fedossejenko, Vessenko, and Oussyskine	U.S.S.R.	Jan. 30, 1934	882,850	(a)	72200
Kepner, Stevens, and Anderson	U. S.	July 28, 1934	3,000,000	51	60613[2]
Cosyns and Van der Elst	Belgium	Aug. 18, 1934	500,000	74	52867
Piccard and Piccard	U. S.	Oct. 23, 1934	600,000	59	57579

(a) Altimeter reading.

[1]Present world's record.

[2]By barometric formula from pressure and temperature observations, 62720 feet; by vertical camera photographs, 62100 feet.

A NEW METHOD OF AUTOMATIC SYNCHRONIZING

Continued from page 88

adjusting rheostat," reading from positive to negative.

As the phase angle increases toward 45°, the vector difference voltage increases less rapidly than in direct proportion to phase angle; the saturation of the compensating reactor tends to correct for this condition.

The *advance voltage* is induced in the secondary of the advance transformer, by the change in primary current of this transformer as the phase angle changes. The connections are made so that when the phase angle is decreasing, this voltage opposes the phasing voltage, the left end in the diagram being negative and the right end being positive.

The *compensating voltage* is produced as follows:

(1) The two source voltages, after transformation, are drawn from the upper secondary of the upper insulating transformer to a rectifier, and from the lower secondary of the lower insulating transformer to a rectifier, as shown in the diagram. This produces two d.-c. voltages proportional to the two source voltages.

(2) These two rectifiers are joined at their negative terminals and each one is loaded by a resistor which provides a path for current to flow in response to the difference between the two voltages.

(3) The difference between the two voltages is fed through a third rectifier to obtain a difference voltage of constant polarity. A small capacitor across the input reduces the ripple component of the voltage difference which exists at all phase angles except zero and 180°.

(4) This difference voltage of constant polarity is fed to a potentiometer for purposes of adjustment.

(5) The compensating voltage is that voltage from the junction of the advance transformer secondary and the compensation adjusting rheostat to the tap on this rheostat, reading from positive to negative. It always opposes the phasing voltage, and is approximately equal to it at 0°.

The *resultant voltage* which controls *D* is the phasing voltage minus the sum of the advance voltage and the compensating voltage. It is applied to two studs of the relay, one of which is negative at 180° phase displacement, zero at a definite *time* in advance of synchronism, and positive from that instant until synchronism is reached; it then reverses and remains negative through 180°.

The amplifier closes the left contact of relay *D* to operate coil of relay *A* when this stud is sufficiently negative, and closes the right-hand contact as the voltage on this stud falls to zero.

The control tube (right hand tube in diagram) responds to the changes in voltage across these relay studs. Changes in d.-c. control voltage affect the compensating (left hand) tube in the same way as the control tube so that they do not affect the difference between the plate currents materially. The windings of relay *D* being connected in opposition, the operating point of the relay is determined almost entirely by the voltage across the relay studs above referred to, and is only slightly affected by the control source voltage.

To recapitulate, it may be said that the complete relay consists of a differential relay *D*, each coil of which is connected to the plate of one tube, an auxiliary relay *B*, actuated by the contacts of *D*, and a checking relay *C* to prevent synchronizing indication being given if the frequency difference is excessive. An auxiliary relay *E* is connected so that if *D* operates after the contacts of checking relay *C* and its time auxiliary *A* have closed, the contacts of *D* finally energize the main auxiliary relay *F* to initiate the closing operation of the breaker. The tube circuits are balanced so that variations of from 80% to 110% of normal in d.-c. control voltage will have no material effect upon the closing angles, and a compensating circuit balances out the effect of voltage differences between the a-c. sources.

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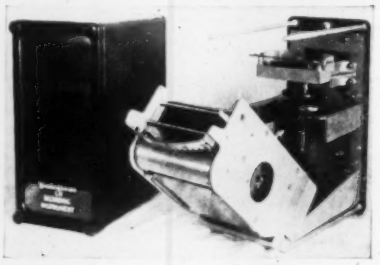

Position Transmitter and Recorder

A duplicate position telemeter system for indicating and recording at a distance the position of mechanisms such as bridges, gates, valves or water level in water power plants, engine governor positions, or the position of any important mechanism, is announced by the Westinghouse Electric & Mfg. Co. The "Type GH" position recorder is assembled in a rectangular case for switchboard panel mounting. An improved duplicate position type of motor operates a direct-acting pen which records on a strip-type chart variations in the position of remotely associated mechanisms operating a motor-type transmitter.

Combination Amplifier

A combination remote and public address amplifier designated as "PAR-19" is announced by the Remler Co. Master gain controls enable the operator to secure any desired mixing combination and

power level on either amplifier, independent of the setting of the other. Transmission is therefore free from feedback and extraneous noises, it is said. The PA amplifier is a 4-stage, push-pull resistance-coupled amplifier, using three type 6A6 tubes, two type 2A3 tubes, and one type 82 rectifier. The remote amplifier consists of a 3-stage, push-pull amplifier using type 6A6 tubes. Both are housed in a portable case measuring 18"x19"x8" and weighing 85 lbs.

Edgewise Indicating Electrical Instruments

A new line of miniature horizontal edgewise indicating electrical instruments, just announced by the Hickok Electrical Instrument Co., consists of d.-c. instruments using D'Arsonval move-

ments, a.-c. instruments using dynamometer movements both said to be accurate to 1½%; a.-c. instruments using moving iron movements with an accuracy of 2%, a.c.-d.c. types using copper oxide rectifiers with accuracy of 5%, and high-frequency thermocouple styles with an accuracy of 2%. Body dimensions are 4¼"x1¾", flange dimensions 5"x2½", depth 2¾". Cases molded of Bakelite with black or walnut finish, flush mounting; with zero adjusters on outside. Scale length is 3¼", and panel space is half that required by round or square instrument of equal scale length. Vertical-shaft design gives all the advantages of the round or square instrument used flat: greater sensitivity, less pivot friction, and less chance of error from accidental unbalancing of the moving system. Movement is built as a separate unit in die casting and is readily removable from base and magnet for servicing. Pole pieces and cores, machined from soft iron, are mounted in the die casting. Pivots and jewels, being affixed to screws, are easily changed when necessary. Magnets are solid and made from aged cobalt steel, tungsten steel, or "oerstit," depending on sensitivity of the movement. Pointers furnished either spade, bar or knife edge; mirror scale supplied if desired. Some ranges can be built for *vertical* operation, the up-and-down scale being preferred on some installations and creating a "different artistic effect."

"Summer-winter" Type Thermostats

Julien P. Friez & Sons, Inc. announces a new line of thermostats for air-conditioning applications. Sensitivity is ±0.5°F. "Summer-winter" manual switches are built in and interwired so that both heating and cooling equipment can be operated. Key operation switches are available for use in public buildings.

Changing the position of the "summer-winter" switch reverses the contact action so that heating equipment is started on falling temperature in the winter whereas cooling equipment started on rising temperature in the summer.

Beat Frequency Oscillator

A scale of >15" arc length, calibrated at sixty separate points against frequency standards, is a salient feature of the new "Type TMV-52-E" beat frequency oscillator announced by RCA Victor Co., Inc. This scale is calibrated from 20 to 17,000 cycles but the range extends beyond, the makers asserting that as far down as one cycle there is no locking in step. Oscillations in this range are produced by beating two rf oscillators, rectified by a detector, and amplified before being fed to the output. The manner of accomplishing each step is said to differ from older practice. Type RCA-840 Radiotrons, employed as radio frequency oscillators, are connected in

electron-coupled circuits of the tuned plate type. Special band-pass filters and a mixing circuit designed to obtain the proper voltage ratio between the fixed and variable frequency oscillators insure a nearly pure sine wave in the detector output. A reed frequency meter provides for calibration adjustments. Open-circuit output is 25 volts and load output is approx. 40 milliwatts. Total harmonic content of this oscillator (as shipped) under load is <5% over the entire range. However, it may be reduced to <2% above 100 cycles. New oscillator is made in portable type (illustrated) and in rack mounting type.

Sound System Testing Apparatus

Testing apparatus to measure the frequency response, etc., of Western Electric Sound Reproducing Systems is now supplied by Electrical Research Products, Inc. as a further means of facilitating high-quality sound reproduction:

The *TA-4145 Test Meter*, Fig. 1, is a copper oxide rectifier type voltmeter in a Bakelite case 3 1/8"x5 1/2"x3" high, weighing 1 3/4 lbs., provided with 3 a.c. voltage scales 0-1.5, 0-6 and 0-1200. In combination with a selector switch, these scales are used for measuring a.c. voltages up to 1.5, 6, 15, 60, 150 and 1200 volts, respectively. An additional scale of 0-10 permits reading of "power levels" in 1 db steps between —18 and +56 db by algebraically adding the 0-10 scale reading to the selector switch db setting. The instrument has a constant non-inductive terminal resistance of 4000 ohms at all selector switch settings except for that associated with the 1200-volt scale where the terminal resistance is 320,000 ohms. All sine wave voltages of commercial power frequencies may be measured to an accuracy of within 5% of full-scale value. Power level measurements of circuits with impedance of 500 ohms are registered at the true energy level in db, but measurements of circuits with other impedances than 500 ohms necessitate a slight correction to the reading.

The *TA-4147 Test Meter*, Fig. 2, is a combination d.c. voltmeter and ohmmeter with a self-contained source of emf. It is enclosed in a Bakelite case 3 1/8"x5 1/2"x3" high and weighing 2 lbs. The potentiometer on the panel permits compensating for changes in potential of the component 4 1/2 volt ohmmeter battery and 10 binding posts are provided for connections. The instrument is equipped with three combined voltage-current scales 0-25, 0-500 and 0-1000, which in conjunction with the associated binding

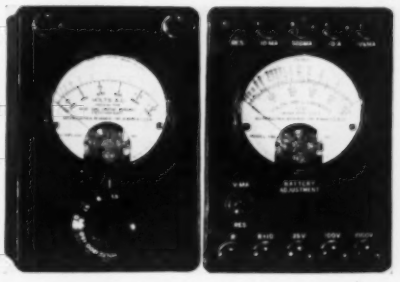

Fig. 1 Fig. 2

posts permit the measurement of currents up to 0.01, 0.5 and 10 amperes d.c., and voltages up to 25, 100 and 1000 volts d.c. An additional scale of 0-100,000, in conjunction with proper binding posts, permits measurements of resistances not exceeding the full scale readings of 10,000 and 100,000 ohms. A small two-position tumbler switch (V-MA and RES.) connects the internal circuit for voltmeter or ohmmeter use. The voltmeter resistance is 1000 ohms per volt.

Selective Relay

In this new device announced by the Gamewell Co., the selectiveness consists in disregarding all impulses except a definitely timed signal. Developed for fire alarm systems and fire pump control, it is finding applications in starting and stopping industrial machinery. The mechanism is of the spring-driven type responding to approximately 60 operations of the controlling electromagnet before it is run down. It should be wound

after each operation of the electromagnet (winding handle provided). Dimensions are 4 3/16"x7 3/8"x6 9/16" high. Magnet resistance is 40 ohms, and the contact capacity 1/2 amp. a.c. or d.c. Two sets of contacts are provided: normally-closed and normally-open. Either set can be used for connections to the circuit to be controlled. Additional contacts are also provided which close when the relay is run down. These contacts can be connected to a local supervisory circuit.

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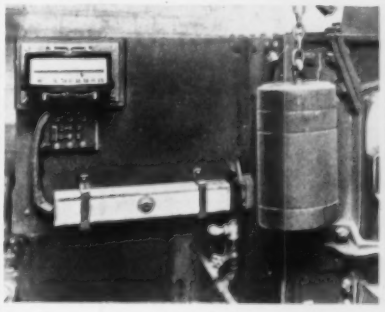
THWING
Radiation Pyrometers



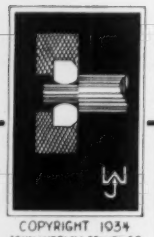
Thwing Radiation Pyrometers are outstanding American made pyrometers for measuring accurately all high temperatures. They are made in portable, stationary wall pattern and recording types.

The illustration shows a Thwing Indicating Radiation Pyrometer installed on a high speed steel heat treating furnace.

Radiation Pyrometers are especially applicable for: rotary kilns in lime and cement plants, hot saw and moving hot objects in steel mills, checker wall and hot batch temperatures in glass plants, continuous kilns in ceramic plants, silicate of soda furnaces, etc.

Write for Bulletin 11

Thwing Instrument Company
3323 Lancaster Avenue, Philadelphia, U.S.A.



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MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

C102 **Vibrating-Reed Tachometers.** Bulletin 1390 tabulates the special characteristics of Frahm vibrating reed tachometers; covers principle of operation, construction, method of reading, proper vibration amplitude, special damping-bar, mounting, amplitude attachment, ranges and intervals between reeds, types of Frahm vibrating-reed tachometers. James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

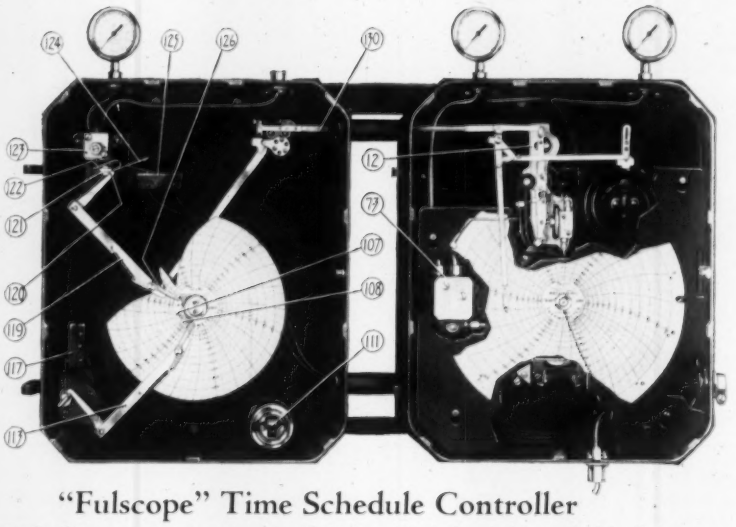
C103 **Rapid Inductance and Capacity Measurements.** Bulletin 100 describes the Type 165 Reactance Meter. Theory and operation are discussed.

C104 **Combustion Controller.** Bulletin Type B briefly describes the Selasette combustion controller for furnace atmosphere control. Selas Co., Philadelphia, Pa.

C105 **Dial Thickness Gage.** Pocket leaflet describes new thickness gage for measuring paper, rubber, sheet metal, card board, veneer, glass, leather, wire, etc. B. C. Ames Co., Waltham, Mass.

C106 **Gravitometers for Gases and Liquids.** 4-page bulletin describes: Recording gas gravitometer, portable gas balance, liquid gravitometer. George Sydney Binckley, 857 S. San Pedro St., Los Angeles, Calif.

C107 **Graphic Instruments in Industrial Research.** Bulletin 1134 discusses the application of recording instruments for testing brakes and brake lining. Esterline-Angus Co., Indianapolis, Ind.

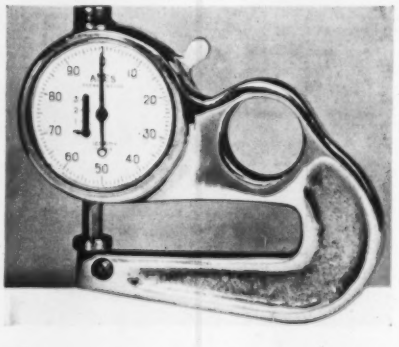


"Fulscope" Time Schedule Controller

Control of temperature, pressure, flow and liquid level (or combinations thereof) according to a predetermined time schedule, is effected by this new instrument brought out by Taylor Instrument Companies. Housing the instrument in two standard cases, rigidly mounted as a unit, permits visibility of both chart and cam, use of large chart size cams and of a simple and sturdy timing mechanism, accessibility of working parts, and separate chart and cam rotations which allow different periods of revolution. The right-hand case contains the recording chart and a "Fulscope" controlling mechanism with universal sensitivity adjuster (see *Instruments*, April 1934, page 81) by means of which process time lag is met and throttling control assured. The left-hand case houses the cam and rotating mechanism and the several auxiliary devices to perform additional functions in the process. The desired time schedule by which the controlled temperature, pressure, flow or liquid level is changed, is cut on the cam: As it rotates, a rider is moved in accordance with its contour. This motion is transmitted through a suitable linkage to the "Fulscope" control system in the right-hand case, to change the control point. This correspondingly varies the air pressure delivered by a pilot air valve to the diaphragm-motor of a control valve, which in turn changes the flow of the controlled medium to the apparatus under control. An auxiliary trip air valve can be operated at the end of or at any point during the process, to turn on or off air pressure to a diaphragm-motor valve. Such an accessory can be used where it is desired to shut off steam and turn on cooling water at the end of the cycle. Also, a trip switch can be combined with this trip valve to sound an alarm when this operation takes place. If a complete schedule does not comprise a whole cam revolution, the cam can be made to continue its rotation to the beginning of the cycle and then be stopped by an automatic clock stopper. A tumbler switch is provided to cut out the cam motor circuit at will. Both cam and chart are rotated by separate electric clocks, which may or may not be of the same periods of revolution.

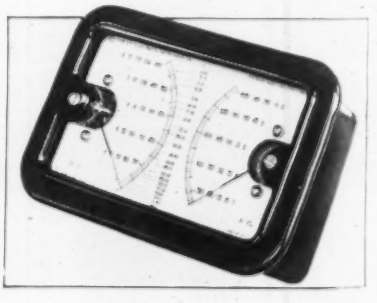
2" Throat Pocket Gage

A deep throat gage that measures thicknesses of sheets 2" in from the edge is announced by the B. C. Ames Co. It can be carried in the pocket, and is quick to operate since the anvils are opened by pressing down the lever at top, and closed with a uniform spring tension by releasing the lever. Capacity for materials up to $\frac{1}{8}$" in thickness. The 2" dial is graduated in thousandths, but finer measurements are easily estimated. A chart attached to back gives fractions and decimal equivalents. The frame is of bronze, chrome plated; the crystal is unbreakable, and other parts are rustless.



Volt-ohm-milliammeter in Kit Form

Announcement by The Triplett Electrical Instrument Co. that its "No. 1206" volt-ohm-milliammeter is now available in kit form, designed for use with built-in shop equipment, will interest service men who desire to assemble their own test sets or who want instruments to meet special space requirements. New instrument is same as "Master Model," except that it does not have the panel, adjustable feature, batteries or case. It is furnished complete with all shunts, resistors, capacitors, coils, drilling template, blue prints and instructions.



Flow Controllers, Proportioners, etc.

Several new equipments are announced by Schutte & Koerting for automatic and manual control of flow rate and proportioning, all of them embodying one or more "Rotameter" flow-measuring devices: Fig. 1 shows an *all-electric flow control system* wherein the primary ele-

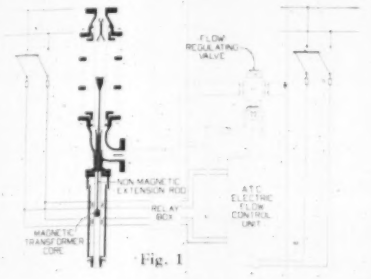
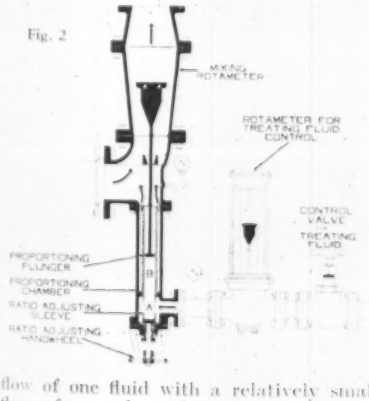


Fig. 1

ment is a "Rotameter" to the rotor of which is attached an extension rod carrying on its lower end a short core piece moving up and down a well with rate variations. Around the outside of the well are coiled two transformers, their primaries connected to an a.-c. source and their secondaries to relays commanding a valve operating unit, such as those made by the Automatic Temperature Control Co. The transformer coils are vertically adjustable, either as a pair or separately, for either rate setting or differential setting. The new *air-operated flow control system* embodies an electric transmitting "Rotameter" somewhat similar to that in Fig. 1 but this is connected to a recording-controlling wattmeter such as that of The Bristol Co., wherein a vane type pilot air valve is actuated, thus commanding a diaphragm-motor valve on the pipe conveying the fluid to be controlled. The recording wattmeter pen serves as an indicator, against which the reading of the float type primary element may be compared at any time for checking the performance of the transmitting system; beside furnishing graphic records of the flow rate on round charts. Rate setting is accomplished by turning a knob in the recording wattmeter case.

The new *automatic proportioners* are entirely self-contained. Fig. 2 shows one system for treating a relatively large

Fig. 2



flow of one fluid with a relatively small flow of secondary fluid. The main flow determines the height of the rotor in the "Mixing Rotameter" and hence the height of a proportioning plunger in a slotted sleeve, thus holding a given ratio of primary fluid and treating fluid. The ratio is set by adjusting the effective width of the slot, this being accomplished by adjusting the extent of coincidence of the slots in the inner and outer sleeves within the proportioning chamber. The arrangement illustrated is used only when the treating fluid flow is $<5\%$ of the primary fluid flow. For higher ratios Schutte & Koerting supply arrangements wherein the mixing of the two fluids takes place after the primary fluid has passed through a "Mixing Rotameter."

For distillation processes a new *Tail Box*, Fig. 3, is announced, consisting essentially of the four parts annotated.

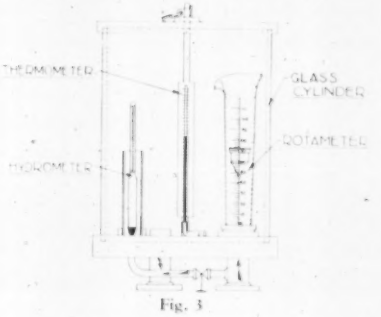
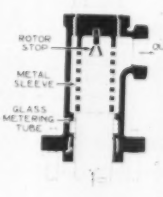


Fig. 3

The top of the flow-metering tube is so shaped that a compact stream pours over one spot without obstructing view from convenient angles.

Rotameter Safety Head

In most models of "Rotameter" flow indicators, the top-like float moves inside a glass tube. In some applications it is found impossible to prevent flow surges when starting up processing units, and such surges cause the rotor to strike the upper end of the tube, fracturing it sooner or later. Schutte & Koerting announce a safety head wherein the upper stop is separate from the glass tube, so that shock is absorbed by the stop and is not transmitted to the tube. A violent surge, in fact, sends up the float beyond the upper end of the glass tube into a metal sleeve.



Thermostatic Steam Trap

Latest addition to "No. 9" series of Sarco differs from others in that it can be used for fluctuating pressure 0 to 200 lbs. in.^{2}, requires no adjustment in the field when steam pressures change, is expressly designed for draining high-pressure coils and jackets of industrial heating and processing equipment.

X-Ray Shield

A new X-ray shield of Bakelite Laminated and lead, developed by Joseph C. Rah & Co., is designed for portable shock-proof X-ray equipment for industrial purposes, such as X-raying castings and joints. The shield is made by wrapping a Bakelite Laminated tube on a mandrel and curing it hard enough to permit machining. A groove is then cut into it and lead foil is rolled in, of thickness depending upon the penetrating powers of X-rays. Additional varnish-impregnated paper is wrapped on, and the whole shield is cured properly. The Bakelite Laminated tube, when tested, was opaque to X-rays generated by 125,000 volts and resisted a flashover of 130,000 volts.

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Illinois Testing Laboratories, Inc.

142 W. Austin Ave. Chicago, Illinois

C108 **Open Hearth Furnace Control.** 6-page leaflet describes complete furnace control for regenerative furnaces. The leaflet tells what the control does, and how. Leeds & Northrup Co., 1901 Stenton Ave., Philadelphia, Pa.

C109 **Absorptiometer for Liquids.** Bulletin AS031 describes an instrument for the rapid and accurate measurement of the absorption of a liquid. P. J. Kipp & Zonen, Delft, Holland.

C110 **Paper Testing Instruments.** Bulletin No. 1420 illustrates and describes the following instruments: Smoothness Tester, Stiffness Tester and the Densometer. W. & L. E. Gurley, Troy, N. Y.

C111 **Electronics and Electron Tubes.** Three publications on theoretical and experimental electronics and electron-tube applications, originally published for educational institutions have now been made available to the public at a nominal charge. "Electronics and Electron Tubes" was written by E. D. McArthur in response to requests from schools and colleges for a publication giving, in easily understood language, the fundamentals underlying the vacuum tube, and including simple experiments to illustrate these fundamentals. References are included which enable the reader to delve more extensively into many subjects treated in the 18-page booklet. Designated as publication GET-568-A, it is priced at 25 cents. The other two publications, GET-566 and GET-620, deal with laboratory experiments on electron-tube theory and on electron-tube applications, respectively. The former is intended as an experimental supplement to McA rthur's "Electronics and Electron Tubes," while the latter is a laboratory manual covering a number of fundamental electron-tube applications. The two booklets are obtainable as a combination priced at 25 cents. Address: Educational Section, General Electric Company, Schenectady, N. Y.

C112 **Pressure Gage Connection.** Leaflet illustrates a pressure take-off which permits making a quick, convenient, tight connection to any pressure line. Walter J. Ottinger, 1892 East 55th St., Cleveland, Ohio.

C113 **Insulation Testing Instruments.** Catalog 1400 describes somewhat in detail the principle of operation of "Megger" insulation testing instruments and 7 different types now available. James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

C114 **Motor Sequencing System.** Catalog Sec. 11, page 161 illustrates a motor sequencing system and automatic pump controller. Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

C115 **Summer-Winter Thermostats.** Bulletin A-X illustrates the thermostat which gives complete control to heating in winter and cooling in summer. Julien P. Friez & Sons, Inc., Baltimore, Md.

INSTRUMENTS
1117 Wolfendale St., Pittsburgh, Pa.

Have me supplied with a copy of each piece of Manufacturers' Literature listed below.

Name .....

Position .....

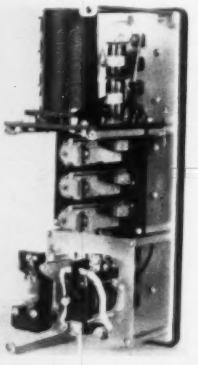
Firm .....

Street and No. .....

City ..... State .....

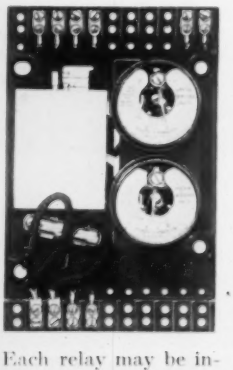
Synchronizing Relay

Featuring automatic compensation for errors due to source voltage difference and control-voltage variations, a synchronizing relay which may be used for either machine synchronizing or line synchronizing in either automatic or manual stations, has been announced by the General Electric Co. Its essential element is an advance transformer operating through a pair of thermionic tubes to control auxiliary relays so that the breaker closure is initiated with the proper advance time, according to the operating time of the breaker, to effect breaker closure near the exact instant of zero phase displacement. (See article by Holland on page 88.) All tubes and the few moving parts (illustrated) are mounted in a 5½ by 16" universal case, and the network components are mounted in an auxiliary box 9½ by 17" supported on the relay studs behind the panel.



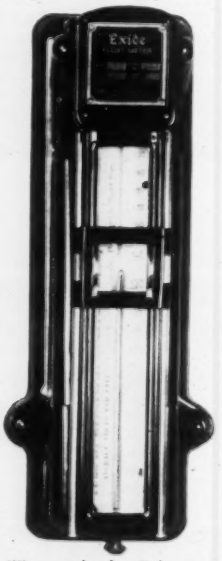
Illumination Control Relay

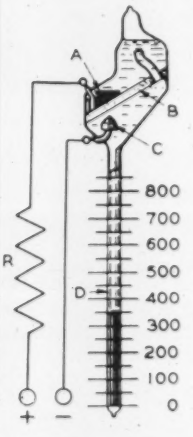
For automatically controlling either outdoor or indoor lighting systems, "Model 709" Illumination Control Relay announced by the Weston Elec. Instrument Corp. turns lights on and off in accordance with the natural light intensity so that a predetermined level of illumination may be maintained. It consists of a small panel on which are mounted two Sensitrol relays, for turning lights on and turning them off. Each relay may be independently adjusted and the value at which it operates may be selected from a calibrated scale. It is said that the advanced design of the contact circuit in Sensitrol Relays permits high sensitivity combined with a relatively high contact pressure. The energy for their operation is obtained from either one or three Weston Photronic cells. When daylight diminishes to a predetermined level the contacts of the "turn on" relay close and complete a circuit to a small induction motor which, in turn, drives a small cam. This cam rocks a mercury switch, completing the lighting circuit. At the same time it locks out and resets the "turn on" relay. The motor stops, leaving the lights on and releasing the "turn off" relay from its locked out position so that when the light intensity rises to the desired operating value, the lights will be turned off. This same procedure occurs when the "turn off" relay makes contact. The entire operation is completed in about one minute. This operating interval prevents continuous operation due to shadows falling upon the Photronic cell. For *street lighting applications* each Sensitrol relay is calibrated from 0 to 2 foot-candles permitting a low operating value of 0.5 foot-candle. A weatherproof light target, containing three Photronic cells, actuates the relays. For *interior illumination control*, the relay panel is assembled in cast aluminum cabinet for wall mounting. A single Photronic cell, enclosed in a suitable case with a glass front, may be mounted in any location desired. The relay scales are calibrated from 10 to 20 foot-candles "turn on" and 20 to 30 foot-candles "turn off" although any range may be supplied. The operating point is selected by simply moving an index arm over the calibrated scale.



Volt-hour Meter

The "Exide Float Meter" has been brought out by The Electric Storage Battery Co. as a means of (1) determining the average voltage of a d.-c. circuit over any definite period of time within the capacity of the meter or (2) indicating from day to day (over a period of either two weeks or one month) whether or not the voltage is being maintained at approximately the proper value. It is particularly adapted for use with batteries which are unattended a large part of the time. It comprises an electrolytic cell in the upper part of the housing, and a measuring tube into which the mercury drops as it is deposited on the cathode. The electrolytic element consists of a mercury anode *A* which rests on a disk of porous glass *B*, the latter allowing comparatively free circulation of the mercuric iodide electrolyte but preventing the mercury from passing through it.

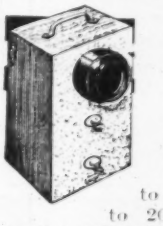




The cathode *C* is a carbon pellet placed just beneath the porous disk. The passage of current tends to plate on the anode an amount of mercury proportional to the current flowing. The mercury does not stick to the carbon cathode but drops into measuring tube *D*. The rate at which mercury is deposited is in turn proportional to the voltage impressed across the terminals of the meter. When the tube is approximately full (or at the end of a shorter period of time) the meter is reset at zero by inverting the element frame which is pivoted near the top of the upper housing. The value of resistance *R* for any given size of battery is such that 0.005 to 0.010 amp. flows through the circuit. The power consumption is therefore ordinarily negligible. As the element is hermetically sealed, there is no appreciable deterioration. The aim has been to secure an approximate accuracy of 0.25% (0.005 volt per cell) in the calculated average voltage. The meter measures 4½"x3½"x11½". It can be sealed against unauthorized resetting or removal. Its principal applications are in connection with "floated" batteries, where it is desired to maintain a recommended average voltage, as in railway signal and interlocking, electric power control, emergency light and power, telephone and other stationary services.

Phototube Relay

Employing a standardized commercial gaseous type phototube, the new relay announced by the Miles Reproducer Co. is self-contained in a portable housing as shown. Three external connections permit either open or closed circuit operation for control of illumination or operation of power relay. External sensitivity adjustment is provided. Relay is rated to operate equipment up to 200 watts non-inductive load at 110 volts d.c. or 600 watts non-inductive load at 110 volts a.c. A-c. model consumes approx. 7 watts; d.-c. model approx. 40 watts; battery model requires two 45-volt "B" batteries.



Apparatus for Mounting Microscope Specimens

The problem of mounting metal specimens, like small wires, sheets, springs, powders, etc., which are to be examined microscopically, has been minimized by research laboratories which have recently perfected a new method of mounting them in Bakelite molded. The process enables a standardized routine and uniformity in grinding and polishing operations. It is said to provide absolute adherence of Bakelite molded to the specimens; freedom from relief polish, margins, or crevices; uniform shape of mounting and convenience of handling; reagent resistance, and time saving and economy. For this purpose a new hydraulic press, Fig. 1, has been designed and developed by the Wilkens-Anderson Co. Any metal specimen can be mounted easily in Bakelite molded (see Fig. 2). The operation is clean and rapid. Various colors may be selected to obtain the best contrast with specimens.

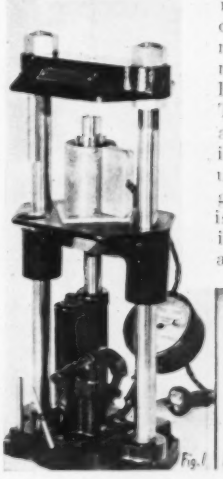


Fig. 1

Fig. 2

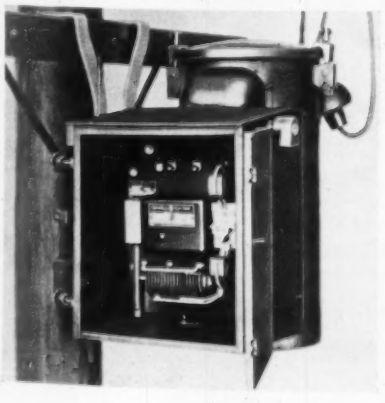
Voltage Regulators

Three new automatic voltage regulators, developed for use on branch feeders and for sections of long feeders, have been introduced by the General Electric Co.:

(1) A new branch-feeder induction voltage regulator provides automatic regulation of branch and rural lines, within limits ranging from a 10% boost to a 10% lower. It operates in the same manner as a conventional station-type induction regulator but, being designed for pole-mounting, requires no land purchase or foundation. Either automatic or manual operation can be obtained. It is built in 12- and 24-kv-a. sizes for 2400-volt, 50- and 100- amp., and 4800-volt, 25- and 50-amp. 60-cycle circuits.

(2) A new branch-feeder step voltage regulator, suitable for pole-mounting, provides four steps of 2½% each, which can be arranged for all boost, all lower, or any combination of boost and lower, within the 10% total range. It is controlled by a contact-making voltmeter acting in conjunction with a motor-relay switch. Through reduction gears, a motor stretches two springs which, when released, pull a moving contact from one position to another at high speed. During the momentary switching interval, the load current is carried by a Thyrite by-pass, providing continuity of service. The control equipment, in a weatherproof cabinet, may be mounted on the tank or at the pole base. By means of turn-button switches, the voltmeter can be disconnected and the regulator operated by manual control of the motor. A dial on the outside of the tank shows the operating position. This regulator is available in 5-, 10-, 15-, and 25-kv-a. sizes, for 2400 and 4800-volt, 60-cycle circuits, 70 amp. or less.

(3) A new branch-feeder step voltage booster (illustrated) provides a single definite boost in feeder voltage when required by periodic heavy demands from domestic peaks or factory-lighting loads. Whenever the voltage on a circuit drops below a predetermined level the booster automatically provides a single boost of either 2½, 5, 7½, or 10%. Then, should the voltage exceed a predetermined upper level, the booster returns to a neutral position and remains there until the voltage again drops below the lower limit. As the tapped portion of the winding has four 2½% sections, the booster can also be connected to provide: (1) a 2½% continuous rise and a 2½, 5 or 7½% automatic boost; (2) a 5% continuous rise and a 2½% or 5% automatic boost; (3) a 7½% continuous rise and a 2½% automatic boost. In addition the winding can be connected to lower the voltage, instead of boost it; or to provide any combination of continuous lower and single automatic boost, or vice versa, within the range of the four 2½% sections of the tapped winding. Switching from neutral to boost position is instantly effected by a double-throw contactor actuated by a resonant voltage relay. This new booster is designed for 2400-volt, 60-cycle circuits of 70 amps. or less, and is available in 5 ratings of 1.5, 3.0, 5.0, 10.0, and 15.0 kv-a.



Precision Transformers

Superlative quality is announced as the principal distinction between the new "Precision DeLuxe" line and the regular line of audio transformers produced by the American Transformer Co. New line comprises 12 models for line-to-grid, 10 for mixing applications, 5 interstage and 8 plate-to-line. Response of all 35 designs is guaranteed uniform within ½ db from 30 to 16,000 cycles but it is said that "a majority" of the designs have far better characteristics. These units are said to "establish entirely new standards for low insertion loss, regulation, constant input impedance at all frequencies, low wave-form distortion, negligible phase shifts and low leakage inductance."

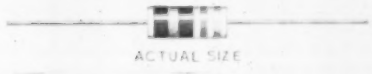
Laminated Contacts

A new electrical contact button made of fine silver backed-up with steel is announced by the General Plate Co. It is stated that these laminated buttons "cost far less and actually wear longer than solid silver." They can be furnished

with back projections to facilitate spot welding to steel, brass or copper supporting members. It is further stated that this type of button does not lose its shape even when contacts vibrate and pound together. They are made with flat or dome contact faces, in all sizes.

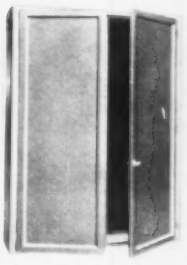
Insulated Resistor

A new ¼-watt insulated carbon resistor announced by the Erie Resistor Corp. consists of a molded carbon resistance unit enclosed in a ceramic case. Leads are brought out at the ends to facilitate wiring and insulation with spaghetti, if necessary. The ceramic insulation is said to eliminate danger of "shorts" even in the smallest spaces. Including the ceramic shell, over-all dimensions (⅛ x 7/16") are smaller than for the corresponding non insulated Erie Resistor. New resistors simplify installation problems; e.g., they can be placed inside I.F. transformer cans without requiring further insulation. They embody improved color coding: color bands completely encircling the ceramic shell, arranged according to RMA standards, and when specified, a fourth band specifying tolerance.



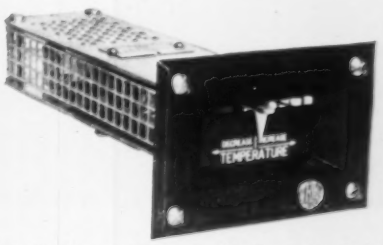
Cabinet Type Panel

A cabinet type steel meter panel equipped with doors to protect and conceal meter and control connections is now being offered by Bailey Meter Co. Illustration shows view from the rear. Electrical connections, control mechanisms and meter adjustments located within the cabinet can be kept under lock and key. One-piece steel plate fronts provide symmetrical and uniform appearance regardless of the quantity or type of meters and instruments installed on them. "Self supporting" construction, which facilitates installation, is secured by bending the sides of the panel back to form supporting wings. In addition, a concealed base flange drilled at convenient intervals provides means for bolting or lagging the panel in place.



Duct Pattern Humidity & Temperature Controllers

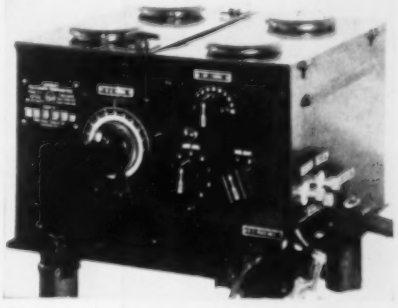
A new line of Insertion Humidistats and Thermostats for air conditioning cabinets, incubators, ducts, laboratory test cabinets, etc., has been brought out by Julien P. Friez & Sons, Inc. Illustration shows the thermostat; the humidistat is



of similar appearance. Both are available either with "Increase" and "Decrease" markings or with graduated setting scales; and in various special forms in a number of electrical contacting types.

Aircraft Transmitter

A new long-distance telegraph transmitter weighing 15 lbs. and delivering a nominal 75 watts of continuous-wave r.f. power to the antenna is announced by the radio division of Westinghouse Electric & Mfg. Co. New "CH" transmitter operates on frequencies ranging from 333 to 10000 kc. by means of plug-in coil assemblies, from the 12-volt battery system of the plane through dynamotor purposely designed for aircraft service.



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If you are unable to find what you require in this section of INSTRUMENTS, write Information Section, Instruments Publishing Company. Give complete information of requirements.

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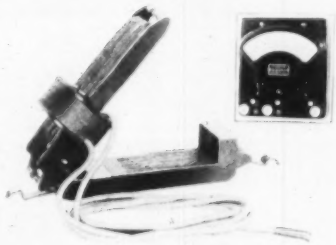

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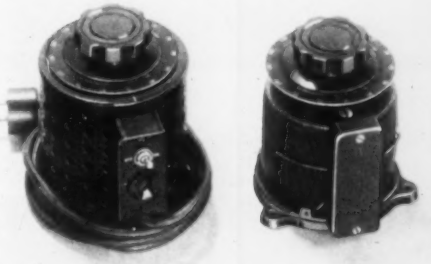

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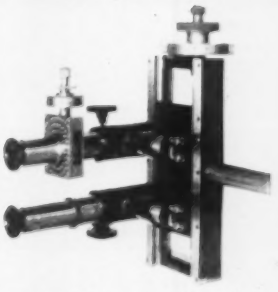

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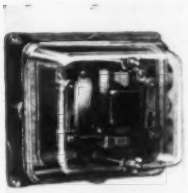

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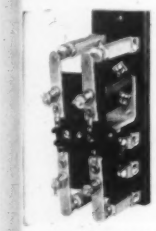
RELAYS



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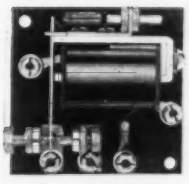

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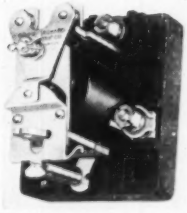

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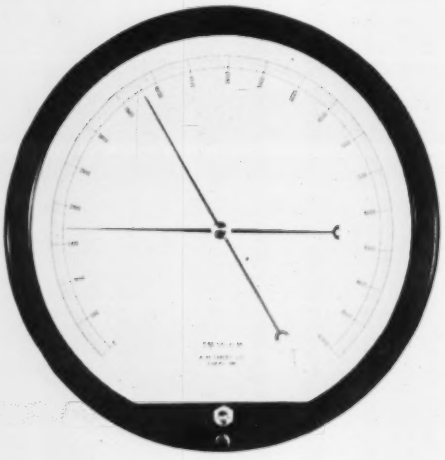

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Spring Book Number

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Directory of Instruments

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THIS directory will be published as a supplement to the June 1935 issue of *Instruments*.

It is planned to divide this Instrument Directory into three parts:

Section 1. *Instruments and Apparatus*

In this section will be listed instruments and devices used for measurement, inspection, testing and automatic control. Under each heading will be put the names of the companies who make and sell it. Anyone who wants to know where he can buy or secure information on a certain product can turn to this section, find the product properly indexed and cross-indexed, see under it the names of the manufacturers who make it.

Section 2. *Trade Names*

In this section can be found the trade name of the product in its proper alphabetical place, with the product it designates and the name of its manufacturer.

Section 3. *Manufacturers' Names and Addresses*

Here will be listed all manufacturers included in the directory with complete addresses.

A questionnaire is being sent by the Instruments Publishing Co. to all manufacturers of instruments and kindred devices. It is urged that each company fill out the questionnaire and return it to us as soon as possible before May 1st. Co-operate with us to make this directory complete.

There is a definite need for a compact key through the entire line of instruments and devices for measurement, inspection and control. Nothing of the sort has ever been compiled before.

INSTRUMENTS PUBLISHING COMPANY

PITTSBURGH, PENNSYLVANIA